Towards an action-oriented model for first year engineering student success. A mixed methods approach.

DISSERTATION

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"… the other students were obviously determined,

and determination is one of those human characteristics that overcomes linear models."

(Cliff Adelman, 1998, p. 42)

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Chapter 1

Introduction

Delft University of Technology is considered to be a top institution by many for a host of reasons: it has a great reputation in the Netherlands for innovative research in design and engineering, it holds respectable positions in prestigious international rankings, and many people in the Netherlands and beyond are familiar with hallmarks of Delft engineering such as the Nuna solar racing car that is designed and managed by its students. Many people are also familiar with the notion that engineering is a tough field of study and that engineering students typically take more time to finish their courses. Within Delft University of Technology this has been known for a long time: students in this university take more, and sometimes much more, time to graduate than the nominal duration of the courses and many of them decide to leave the university before they graduate.

Delft University of Technology (DUT) has strived to improve its graduation rates and to decrease average time to graduation for many years. There have been studies to map the size of the problem and to understand specific issues believed to pertain to the problem, and there have been all kinds of initiatives, innovations and interventions in the education offered at DUT to mitigate the problem, some of which will be discussed in chapters 2 and 8. Most of these initiatives can be regarded as state of the art, at least at the time they were designed and implemented, and some of them have been monitored and evaluated. Still, in spite of all its efforts, the university has proven to be unable to make any significant changes to its graduation rates, attrition rates and time to graduation in over 60 years.

1.1 | Global issues, local solutions

Non-persistence of students is a relevant problem in all kinds of higher education and it is neither limited to the Netherlands nor to engineering, however, graduation rates for engineering tend to be lower in most countries and universities compared to non-enginering courses. This is considered to be a problem for the wider economic health of a nation, e.g. competitiveness in the economy and affluence in societies, by the European Commission (2004) and by the American Committee on Prospering in the Global Economy of the 21st Century (2007). Ohland et al. (2008) show that at a number of leading American universities of the students that enrol in engineering about 50 per cent of the students leave their courses. In the Netherlands there are three research universities of technology[1] offering degrees in engineering. The graduation rates at these universities are around or below 50 per cent six years after first enrolment. This is not uncommon for in the Netherlands, as will be discussed in chapter 2. The conditions under which these similar graduation rates emerge, are quite different: American universities tend to be highly selective of their students and are costly in terms of tuition, while in the Netherlands all students who finish their university preparatory education (UPE) in the designated subjects[2], are entitled to a place on the university course of their preference. There are some exceptions, for instance medicine where there is a *numerus clausus* system in place. Differences between education systems also emerge from the position universities have in society, how they are funded, what options students have to choose a major once they are enrolled, how many times they can resit exams, etcetera (see e.g. Bereday, 1964; Standaert, 2007).

Between and within universities there are again major differences that have profound effects on the organisation of courses and the options that students have (Becher, 1994; Lattuca, Terenzini, Harper, & Yin, 2010). Understanding the issues of student persistence and possible solutions to student attrition therefore need to be found locally. In this research we propose to look for solutions at the level of the individual university.

1.2 | Engineering education as the focus of research

Engineering education stands out from other education in universities because engineers are trained to apply scientific knowledge and principles to design solutions for problems in technology and society. This contrasts with the learning goals of courses in general universities where students are primarily trained to be scientists or take arts based courses (Van Peursen, 1969). These differences will be explored in more depth in chapter 2, where

1 In the Netherlands a distinction is made between research universities and universities of applied sciences, where students are trained for a profession. In this dissertation when we refer to universities, we mean research universities.

2 Students in UPE choose one of four 'profiles', predetermined combinations of subjects in the areas of culture and society, economics and society, science and health and science and technology. Science and Technology, and in some cases Science and Health, are permissible pofiles for enrolment in universities of technology.

we argue that this difference leads to differences in how curricula are designed and that there is reason to assume that different academic cultures and student populations cannot be compared well. Based on these premises, in this research Dutch engineering education is treated as separate and relatively unexplored research territory.

1.3 | The importance of the first year in university

The first year of university marks a large transition in a student's life. Many students leave the safety of their parental house. If students do not leave their parental home, they are usually stuck with long commutes. Students leave the structure of a middle school system they have been participating in for a number of years, they have to become independent, as they start new education courses in which there are many unknowns. They have to create a new network of friends, adapt to new ways of living, and so on. Engineering students, due to the demands of a typical engineering curriculum, with long hours of practicals and project work, and high paced high level engineering classwork, may feel overwhelmed at the start of their programmes (Seymour & Hewitt, 1997; Sheppard, Macatangay, Colby, & Sullivan, 2009). Many students need time to figure out what is expected of them in this new environment and how to cope with it (Kift, 2003; McInnis, James, & Hartley, 2000; M.L. Upcraft, Gardner, & Barefoot, 2005).

The first year of university study in the Netherlands is also a year of selection and students cannot afford to spend a lot of time adapting to their new surroundings as they are expected to obtain credits from early on in the year. As a result of the stacked curriculum, students have few opportunities to mitigate the results of delays or failed exams (Sheppard et al., 2009). Researchers from the Technische Hogeschool Delft (1959) found that once students were delayed, they would commonly not be able catch up. Up until 2009 DUT did not have any procedures in place to enforce the selection process in the first year. In the academic year of 2009, however, the university implemented its Binding Recommendation on Continuation of Studies[3], which prevents students who do not obtain a certain number of credits in their first year from continuing in their second year.

Mendez, Buskirk, Lohr and Haag (2008) and Jansen, Willemsma and Van der Hulst (2000) report that academic success in engineering is influenced by initial success, Baars (2009) reports that this is also the case in medical education and DesJardins, Ahlburg and McCall (2002) found a similar outcome in a large general university in the USA. Beekhoven, De Jong and Van Hout (2002) report that the expectancy students have of how long they will need to complete their course affects when students obtain their first year diploma. These findings are supported by other research such as that of: Upcraft, Gardner and Barefoot (2005), Kuh (2005), Kuh, Kinzie, Buckey, Bridges and Hayek (2006), Pascarella and Terenzini

[3] Binding Recommendation on Continuation of Studies in Dutch is called Bindend Studieadvies, in short BSA, which is the term that will be used in this dissertation.

(2005), Nora, Barlow and Crisp (2005) and Krause, Hartley, James and McInnis (2005). The importance of doing well as a first year student creates tension: students need to have time to adapt to their new surroundings and at the same time there is the pressure to achieve. If an institution for higher education wants to influence its student success rate, the first year is an obvious starting point. It is therefore of paramount importance to institutions to determine which first year student experiences matter to a student's success and how the institution could influence these experiences.

1.4 | Objective and relevance

As student success is among one of the most widely studied areas in higher education, there is an established body of knowledge base on this topic. The research presented in this thesis is firmly rooted in that knowledge base, but it also adds to it. The research that constitutes the knowledge base has not led to any lasting and consistent improvements in retention and graduation rates. Most of the studies done in the field "*have been cross sectional descriptive studies with a focus on appealing theoretical concepts and redundancy in models, rather than a focus on potential implementation of the concepts in practice*" (Tinto, 2012, page 5). Stakeholders are commonly not involved in the research, as most comprehensive studies on the subject are solely based on quantitative analysis. In addition, little is known about student success in the context of engineering education. Therefore our objective was to develop a situated model that aids in understanding and explaining student success in Delft University of Technology and as such, can be used as a tool for understanding and designing educational policy. This study was limited to first year student success only, as success in this year is a good predictor of success in later years (Baars, 2009; DesJardins, Ahlburg, & McCall, 2002; Jansen et al., 2000; Mendez et al., 2008; Willemsma, Jansen, & Van der Hulst, 2000).

For DUT this research will result in a model that can serve as a tool to support designing policies and to assess potential effects such policies may have. Potentially this can create more effective policies and more success, which is also beneficial to the wider society. The research questions are introduced and elaborated on in chapter 4, after exploring the DUT case of persistence and non-persistence and reviewing the literature on this topic.

1.5 | Research approach

1.5.1 | Philosophy of science framework

The scientific philosophical framework serves as the basis of any scientific endeavour. In a framework important issues underlying a scientific project are addressed: how the researcher views her or his position in relation to the world and what can be studied (ontology), how she or he views the resulting relationship between this position and how knowledge is developed (epistemology) and the implications for how this knowledge can and should be pursued (methodology). Two opposing paradigms shape most research: these are positivism and interpretivism. These paradigms are illustrated in Table 1.1.

Popper suggests a third view to this dichotomy. This third view "*preserves the … doctrine that the scientist aims at a true description of the world, or of some of its aspects, and at a true explanation of observable facts; and combines this doctrine with the … view that though this remains the aim of the scientist, he can never know for certain whether his findings are true, although he may sometimes establish with reasonable certainty that a theory is false.*" (Popper, 2010, p. 154).

Table 1.1 | Basic characteristics of positivism and interpretivism. *(Adapted from Cohen, Manion, & Morrison, 2011 and Huang, 2013; based on Weber, 2004).*

Meta theoretical assumptions about	**Positivism**	**Interpretivism**
Ontology	Person (researcher) and reality are separate.	Person (researcher) and reality are inseparable (world).
Epistemology	Objective reality exists beyond the human mind. There is one-to-one mapping between research statements and reality.	Knowledge of the world is intentionally constituted through a person's lived experience. Interpretations of research object match lived experience of object.
Methodology	Abstraction of reality, especially through mathematical models and quantitative analysis and statistics.	The representation of reality for purposes of comparison. Analysis of language and meaning through mostly qualitative methods: hermeneutics, phenomenology, ethnography, etc.
Research object	Research object has inherent qualities that exist independently of the researcher.	Research object is interpreted in light of meaning structure of person's (researcher's) lived experience.
Focus of interest	What is general, average and representative.	What is specific, unique, deviant, and particular.
Validity	Certainty: data truly measures reality.	Defensible knowledge claims.
Reliability	Replicability: research results can be reproduced.	Interpretive awareness: researchers recognize and address implications of their subjectivity.

Popper moves away from hard-core positivism and embraces the subjective worldview common in interpretivism, but he sticks to the idea of basing explanations on observable facts. This view has become known as post-positivism. Eisner and Peshkin (1990) bring forward that both the positivist and interpretivist paradigms have a place in education research, but that there are various positions on how these two paradigms are related. This research is built on the post-positivism paradigm of Popper, as we appreciate that students do not live in an 'objective' world, but rather in an experienced one (Prosser & Trigwell, 1999). At the same time we believe that researchers should confront their own interpretations with those that can be observed and, like Eisner and Peshkin (1990), we believe that methods used in both research paradigms have their merits.

Roth and Ercikan (2009) argue that a central issue in choosing a research approach in education may be the usefulness of different types of data and descriptions to different stakeholders in the educational enterprise. What is useful information to researchers, for instance information on the statistical reliability of a relation between two variables, may not be useful to policy makers and teachers who are interested in forms of knowledge that are simultaneously sufficiently general to provide them with trends and with forms of knowledge that are sufficiently specific to allow them to design instructions to meet the specific needs expressed in the variation from the trend.

In this research the particular and the trends are of interest to the audience for which the research is intended. The particular is important to allow us to design a situated model that takes into account the idiosyncrasies of first year engineering education in DUT. The trends are important to allow us to assess policies to increase student retention and time to graduation and their effects prior to implementing such policies within this context. In this research we combine qualitative and quantitative methods into a 'mixed methods' approach (Cohen et al., 2011; Creswell, 2009), where we use the strengths of both the positivist and interpretivist approaches to complement the other.

1.5.2 | Overview of methodology

The first step towards a situated model was to determine which variables needed to be included in the model. Therefore we explored the DUT case of student success and we studied the knowledge base on student success in engineering and outside engineering. Next we explored what factors and variables mattered to the success of first year DUT students. This was done through a small scale qualitative study based on group interviews with students from cohort 2009. These findings were triangulated (Cohen et al., 2011; Creswell, 2009) in a qualitative follow-up study with a larger group of participants recruited from student cohort 2010. The outcomes were used to create a preliminary model for student success.

The model was then tested and improved where necessary using a quantitative approach using data collected through a survey, and combined with data on curriculum organisation and student progress data taken from the central DUT administrative system. The model was tested using structural equations modelling techniques. The final step was to use the model to assess policy measures specifically intended to increase student success to learn whether the model was fit for this task and to learn where it needed improvement.

1.6 | Outline of the thesis

In chapter two the case of DUT student success is explored by looking at graduation rates and by contrasting them with the graduation rates in other universities and fields. We go on to explore the need to study engineering education success as a separate field of study and to look at previous interventions to increase success in DUT. In chapter 3 we explore the existing knowledge base on student success, with a focus on the value of using models to enhance our understanding of this phenomenon. Based on the outcomes of chapters

2 and 3, in chapter 4 we pose the research questions that will guide the empirical studies and give a detailed description of the methodology. The first exploratory study with students from cohort 2009 is reported in chapter 5, and the second study with students from cohort 2010 in chapter 6. The preliminary model for DUT first year student success and the statistical analysis of this model are reported in chapter 7. In chapter 8 we use the model for case studies of a limited number of policy measures. The final chapter consists of conclusions and a discussion of our findings and recommendations for future research[4,5].

[4] The author of this dissertation published parts of this dissertation in journal papers and conference papers. The publication list is included in this dissertation.

[5] In this dissertation the word 'course' is used to indicate a course programme and the word 'subject' is used to indicate the modules that constitute the course.

Chapter 2

An exploration of the Delft University of Technology retention case

In this chapter we explore the size and the scope of the problem of student success, or lack thereof, at Delft University of Technology. To frame the problem the wider context also needs to be examined. Therefore the first section of the chapter consists of a review of the size of the problem in DUT and in section 2.2 a comparison is made with retention rates of other universities of technology and general universities in the Netherlands. Next the differences between science, technology, engineering and maths (STEM) and the non-STEM disciplines are reviewed in section 2.3, by looking at the differences in learning goals and curriculum design and other differences that may affect institutional retention rates. In section 2.4 we focus on Delft institutional action to date and its success so far. In section 2.5 we take a closer look at two recent institutional policies designed exclusively to increase student success: the Binding Recommendation on Continuation of Studies and the Bachelor before Master Rule.

2.1 | The case of Delft University of Technology

2.1.1 | A call for action

In 2003 the Board of Executives of Delft University of Technology appointed a group of dedicated staff members to list the problems and challenges the university faced while implementing its bachelors' and masters' courses. The group also reported a number of goals that they believed DUT should strive for if it was to maintain its position as a world-class institute for engineering education. In their report the expert group explicitly mentioned the need to reduce student attrition rates and the need to decrease the time students take to graduate:

"Delft University of Technology wants to contribute to society's appeal to increase the intake of students in natural sciences and engineering by attracting more students to the bachelor courses and to decrease dropout. … Furthermore, the university will try hard to raise the retention index and the decrease the time to graduation. The attainment index should lay around 80 per cent in four years from cohort 2006 onwards. … For that matter, society's appeal is not the only driving force behind this initiative. The increase of student numbers is also necessary to maintain a healthy financial basis for the benefit of education and research. The decrease of student numbers will manifest itself in a steady decrease of revenue."
(Commissie Onderwijsportfolio, 2003, p. 25)

The group implied that 80 per cent of a student cohort should graduate within four years for a three-year bachelor course, however, the average percentage of dropout in years before 2003 lay at around 35 per cent and the time to graduation only seemed to increase at that time, as can be seen from Table 2.1 which shows the graduation rates and average time to graduation for DUT student cohorts 1988 to 2008.

The committee's call for action on retention resonated with a similar call from wider society to increase the output of engineers on the labour market. In 2003 the Department of Education, Culture and Science released the 'Delta plan', a plan of action to increase the number of workers with technological or engineering training, following the intentions stated in the Lisbon Treaty to transform Europe into a knowledge-based economy and society (Ministerie van Onderwijs, Cultuur en Wetenschappen, 2003).

The need for more engineers was also observed by the European Commission who noted the growing demand for highly skilled workers with backgrounds in engineering and sciences (European Commission, 2004). These high level reports called for training larger numbers of technically skilled people, scientists and engineers at all levels of education. One way of achieving this is to increase the number of students, another way is to decrease student departures from institutions teaching these disciplines.

2.1.2 | Changing times, unchanging attrition

The challenge to train large numbers of engineers is not unprecedented, nor is the issue of attrition only observed by the Commissie Onderwijsportfolio. In the early 1950's Delft University of Technology (DUT) also invited a panel of professors to study dropout and delays at DUT. The panel consisted of professors in education and psychometrics and they observed that since 1945 the issues of study failure and study delay kept drawing attention. Between 1930 and 1947 on average of 43 per cent of the students left the university without a diploma (Technische Hogeschool Delft, 1959)[6]. The panel studied the student cohort of 1949 in depth. The attrition rates, or rather 'retention index'[7], and delays of this student cohort are shown in Table 2.1. Delay is defined as "being two years behind schedule".

Table 2.1 | Dropout and delay rates 4 years after first enrolment for TU Delft cohort 1949. *Source: TH Delft, 1959*.

	N	Percentage
Nominal students	389	56
Delayed students	141	20
Failed students	166	24
Total	696	100

Researchers followed up on the students that were delayed in 1957 and found that only 19 per cent of those students delayed in 1953 had managed to obtain their diploma. This meant that less than 60 per cent of student cohort 1949 had obtained a diploma 8 years after first enrolment. None of the students had managed to make up for the delay they had already had in 1953. This study will be discussed in more depth in section 2.4.1.

In the 1960-s Dutch universities started to enrol larger numbers of students as a result of general population growth and policies aimed to make higher education available to the masses. Around the inception of the Scientific Education Act in 1960 about 40.000 students were enrolled in Dutch universities (Wiegersma, 1989). Student participation in higher education consistently increased and in 2009 about 233.000 students are enrolled in Dutch universities: a six-fold increase in 50 years (Centraal Bureau voor de Statistiek, 2014). With this large increase in influx of students the financial side of tertiary education came to play a more important role in national and institutional policies, leading to a prioritizing of dropout and delay as serious problems that needed attention (Wiegersma, 1989). Appendix 1 contains an overview of the increase of enrolment at Dutch higher

6 Until 1986 Delft University of Technology was called 'Technische Hogeschool', to indicate its roots as a polytechnic school. It was recognised as a university and was allowed to grant students the degree of doctor.

7 The retention index refers to the relative yield of graduates in a school or course (De Groot, 1970). In this research the words retention and attainment are used interchangeably. There are many different terms used across the world to indicate a similar concept (Van Stolk, Tiessen, Clift, & Levitt, 2007), like 'persistence' and 'completion'.

education and the most important legislation reflecting the changing emphasis from equal access and education for the masses to efficiency, controllability and cost reduction.

Table 2.2 | DUT cohort and size, attainment index per 31-8-2008, average time to graduation, percentage of students finished in n number of years (cumulative). *Source: Technische Universiteit Delft, 2010.*

Master/ doctoral attainment indices: full time students with university preparatory education (UPE) diplomas								
Cohort		**Attainment index per 31-8-2008 in %**		**Average graduation time (years)**	**Percentage graduated within n years (cumulative)**			
Year	**Size**	**Graduated**	**Enrolled**		**5**	**6**	**7**	**8**
1988	2060	64	0	6,6	5	29	51	58
1989	2051	62	0	6,8	4	27	46	54
1990	1923	63	0	6,9	3	23	43	53
1991	2080	63	0	6,7	7	29	46	54
1992	1878	66	1	6,8	6	27	44	56
1993	1801	62	1	6,8	7	24	42	52
1994	1730	64	1	7,1	3	14	36	51
1995	1590	63	2	7,3	2	12	33	48
1996	1595	66	3	7,1	3	13	32	48
1997	1611	62	5	7,1	2	13	32	49
1998	1636	62	5	6,9	2	13	33	48
1999	1550	53	12	6,7	3	11	28	45
2000	1395	45	23	6,2	1	10	28	45
2001	1306	27	39	5,6	1	9	27	NA
2002	1154	8	57	4,8	1	8	NA	NA

Note: When this table was compiled, there were still a considerable number of students from cohorts 1999 and onwards enrolled, which distorts the average graduation times of these cohorts.

The graduation index of the cohorts from 1988 to 2000 seems to be fairly stable as is shown in Table 2.2, but time to graduation has increased over time. This is partly explained by a change in the structure of higher education in 1993: in this year the curricula of technical studies were changed from a four-year curriculum to a five-year curriculum. In the same year a new grant system was introduced. This system was intended to decrease time to graduation by giving students loans that would partly be turned into gifts if students complied with requirements to obtain a certain number of credits in a set period of time.

The data in Table 2.2 shows a notable discrepancy between column 3, showing the total percentage of all graduates from a student cohort in 2008, and column 9 in which the cumulative percentage of students who have graduated in eight years after first enrolment is shown. For instance in the 1994 cohort, 14 per cent of the students needed over 8 years to finish their courses. The retention index for this cohort was 64 per cent, with an average time to graduation of 7.1 years. On average that is 1.8 times longer than the allocated time for the course of study. Table 2.2 shows the cohort size, attainment index, and the average time to graduation for the Delft student cohorts from 1988 to 2002[8,9]. Table 2.3 shows retention indices and time to graduation for 6 courses at DUT, for the undivided courses and the bachelor courses. These tables show that the graduation rates for courses within Delft differ to some extent and that there are major fluctuations between the years.

The percentage of students who graduate in the nominal duration of their course has increased over time, but has stabilised at about 25 to 30 per cent of the students on the courses. This goes for the undivided master and for the bachelor degrees. A possible explanation for the low percentages of graduation within the nominal duration of the bachelor courses in the first years after they were implemented, is that many students did not bother to apply for their bachelor diploma after having fulfilled the requirements. At that time, students could move on to a master's course without having to show the diploma. A grade list was sufficient to be registered in a master course, and even that often remained unchecked, if students had an intake interview in the first place. It is likely that part of the fluctuations in the numbers can be attributed to noise resulting from the transition to a new system: a drop in graduation rate is common in the student cohorts that start just prior to a major intervention. The numbers for the bachelor courses show interesting similarities to the numbers for the undivided courses: the graduation rates three years after the nominal duration of the mechanical engineering and applied physics courses for instance range between 50 and 60 per cent. For most courses the percentage of students that move on to the second year is smaller in the bachelor courses, but the graduation rates for these courses are slightly higher than for the undivided courses. This could indicate that those students who made the wrong choice of field or those students who struggled because of the level of the course, decided to leave earlier in this new system. At this time there is no information available on the graduation rates of later student cohorts in the bachelor courses.

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8 Following the Bologna Declaration the Netherlands implemented the Bachelor and Master structure in 2003. Before that time Dutch universities offered undivided 'doctoral' courses that would lead to a qualification that is considered to be the equivalent of a master's degree. After the implementation of this new system students who had first enrolled under the old regime could finish their studies under some conditions, but they could also submit to the new regime and obtain their bachelor degree. The data on the undivided and bachelor courses are presented separately, because the nominal duration of those courses are different.

9 In university preparatory education (UPE) a far-reaching measure was introduced: the "Tweede Fase", or second phase. The goal of this measure was to create more coherence between subjects, to modernize the content and curriculum and to give schools more options to create their own policies (Inspectie van het Onderwijs, 2003). In practice this meant that student could no longer choose their own combination of subjects to sit exams in, but instead they chose one of four 'profiles', predetermined combinations of subjects in the areas of culture and society, economics and society, science and health and science and technology. Some old subjects were replaced with new ones. Student cohort 2001 was the first cohort that was trained exclusively in the Second Phase course. Along with the inception of the Tweede Fase the Ministry of Education advised to adopt new didactical models to induce more independent study from students as a preparation for life long learning. For a number of years the Ministry changed guidelines and exam programmes on a regular basis (Commissie Parlementair Onderzoek Onderwijsvernieuwingen, 2008). This means that the secondary school preparation of students from 2001 has been very different from that of the preparation of older student cohorts.

Table 2.3 | Cohort and size, percentage of students continuing in the second year, average time to graduation, percentage of students finished in n number of years (cumulative) for undivided Master and Bachelor courses. *Source: VSNU, 2014*

Faculty	Cohort		Percentage continuing in 2nd year	Percentage graduated within n years (cumulative)			
	Year	Size		5	6	7	8
UNDIVIDED MASTER COURSES							
Applied Physics	1995	112	78	1	18	34	49
	1996	81	93	2	14	38	53
	1997	91	87	2	27	49	52
	1998	64	83	19	36	48	53
	1999	68	78	21	41	50	53
	2000	52	90	25	44	50	63
	2001	49	78	20	31	43	49
Industrial Design Engineering	1995	212	88	0	8	25	49
	1996	246	92	0	6	38	52
	1997	253	86	0	25	43	57
	1998	223	88	15	30	47	60
	1999	219	82	25	37	52	58
	2000	246	80	19	36	50	61
	2001	217	82	13	35	58	58
Electrical Engineering	1995	104	88	4	21	34	47
	1996	101	91	10	21	35	50
	1997	86	80	3	23	37	47
	1998	84	79	29	39	44	49
	1999	67	84	34	43	49	57
	2000	54	83	33	44	52	59
	2001	52	73	23	31	35	40
Computer Science	1995	53	83	4	19	36	43
	1996	68	91	6	21	31	40
	1997	99	79	8	22	34	42
	1998	137	82	13	24	36	45
	1999	129	77	22	35	44	48
	2000	113	80	30	43	50	57
	2001	110	75	26	37	45	51
Civil Engineering	1995	334	89	0	12	44	49
	1996	338	92	1	19	30	32
	1997	336	85	3	21	28	33
	1998	309	78	19	32	40	44
	1999	283	83	30	47	58	60
	2000	264	83	31	54	59	63
	2001	230	84	44	57	60	64

Faculty	Cohort		Percentage continuing in 2nd year	Percentage graduated within n years (cumulative)			
	Year	Size		5	6	7	8
UNDIVIDED MASTER COURSES							
Architecture	1995	316	87	0	4	28	48
	1996	351	91	0	7	36	60
	1997	322	91	1	23	56	70
	1998	344	88	19	43	62	67
	1999	311	85	35	50	58	63
	2000	274	83	34	43	55	61
	2001	223	82	23	36	48	56
Mechanical Engineering	1995	124	89	1	8	27	49
	1996	133	87	2	9	25	44
	1997	133	86	0	23	43	56
	1998	128	82	15	31	44	54
	1999	121	80	17	26	41	46
	2000	103	86	12	29	43	52
	2001	133	85	26	40	54	63
BACHELOR COURSES							
Applied Physics	2003	68	78	0	14	32	75
	2004	79	76	6	23	43	84
	2005	87	77	8	31	48	76
	2006	98	78	7	28	41	60
	2007	89	71	18	37	59	NA
	2008	101	76	8	40	64	NA
Industrial Design Engineering	2003	197	84	4	21	57	72
	2004	194	84	5	35	50	66
	2005	217	84	9	32	49	68
	2006	227	78	9	30	51	NA
	2007	276	80	11	47	63	NA
	2008	288	82	12	51	67	NA
Electrical Engineering	2003	50	77	13	30	43	65
	2004	50	75	21	40	47	67
	2005	44	71	24	38	57	73
	2006	45	68	30	41	68	76
	2007	47	79	24	41	51	NA
	2008	60	67	17	41	57	NA
Computer Science	2003	91	75	15	33	51	71
	2004	78	75	24	30	39	71
	2005	58	66	19	3	54	79
	2006	75	79	10	27	44	59
	2007	76	73	21	42	59	NA
	2008	111	74	17	43	54	NA

Faculty	Cohort		Percentage continuing in 2nd year	Percentage graduated within n years (cumulative)			
	Year	Size		5	6	7	8
			BACHELOR COURSES				
Civil Engineering	2003	132	77	10	33	56	77
	2004	157	77	7	24	51	78
	2005	159	78	19	34	55	82
	2006	180	75	44	31	56	78
	2007	222	80	14	40	71	NA
	2008	286	76	12	46	67	NA
Architecture	2003	367	79	0	13	22	77
	2004	349	78	2	14	29	73
	2005	332	75	7	18	40	77
	2006	297	77	3	22	54	76
	2007	395	80	6	45	73	NA
	2008	456	81	11	51	76	NA
Mechanical Engineering	2003	215	79	3	17	37	74
	2004	238	78	4	17	37	72
	2005	280	75	5	19	34	76
	2006	251	77	8	20	39	74
	2007	286	80	8	29	54	NA
	2008	336	81	10	35	54	NA

Note: This table contains data of students with UPE background only. NA = not available. The numbers for the cohort size for cohorts 1995 to 2001 are slightly different from those in Table 2.2. This has to do with changing definitions as used by the VSNU.

2.1.3 | Delft University of Technology courses and student population

In 2012 Delft University of Technology enrolled some 17.500 students in total, of which 3300 students were enrolled in their first year (Technische Universiteit Delft, 2014). DUT is organised in 8 faculties: Architecture, Industrial Design Engineering, Technology, Policy and Management, Applied Sciences, Electrical Engineering, Mathematics and Computer Science, Mechanical, Maritime and Materials Engineering, Civil Engineering and Geosciences, and Aerospace Engineering that offer a total of 14 bachelor and 33 master curricula in science and technology. The bachelor courses are: aerospace engineering (AE), civil engineering (CE), applied earth sciences (AES), electrical engineering (EE), computer science (CS), mechanical engineering (ME), maritime engineering (MAE), industrial design engineering (IDE), architecture (AR), applied physics (AP), Systems Engineering, Policy Analysis and Management (SEPAM). Some courses are organized and taught in conjunction with the University of Leiden, i.e. Life Science and Technology, Molecular Science and Applied Maths. Although women make up approximately half of the population of most universities, women around the world are underrepresented in engineering (Ross et al., 2012; UNESCO, 2013). In DUT Architecture and Industrial Design Engineering attracted between 40 and 50 per cent female students in 2013, while the other courses attracted between 10 and 20 per cent female students (Technische Universiteit Delft, 2014).

With the inception of the Second Phase in UPE in 2001, see footnote 7 on page 18, DUT had to change the entry requirements. At first students with Science and Health (S&H) profiles or with Science and Technology (S&T) profiles were admitted, although the S&H students lacked adequate mathematical preparation. From 2009 onwards only students with a S&T profile or equivalent have been admitted. Students insisting to study at DUT are advised to take extra advanced maths classes (Wiskunde D), but this course is not available at all schools for UPE.

2.2 | Differences among courses in Delft University of Technology and other Dutch universities

2.2.1 | Differences between universities of technology

In the Netherlands there are three universities of technology: DUT, Eindhoven University of Technology (TUE) and Twente University (UT). Table 2.4 shows attainment indices of these three universities on seven, undivided and bachelor, courses that are offered at at least two of these three universities.

It has to be noted that the definition of a 'student' is not as clear-cut as it seems and that over the years a number of different definitions have been used. For instance, administrators can decide to count only those students who registered for an exam and leave out the no-show students who enrol but never show up at university. These unclear definitions, administrative rules that are not always completely clear on how to register every student and changes in policies over the years have left retention data and data on graduation rates polluted.

We showed some of the data on cohorts from 1995 to 2001 to two officers from DUT who were involved in administration in these years. One of them did not recognize the data and believed the percentages of graduation were on the low side. Neither had any clear explanation for the fluctuations in the rates over the years and among the courses. Still, this data was provided by the Association of Dutch Universities and is considered to be the best available.

The range of graduation percentages over the years within a single course of study in Delft, e.g. computer science, varies between 40 and 57 per cent over the course of 7 years. For all of the courses the range of percentages is quite large. There seems to be a deviation from the trend in 1998: all courses in Delft show a rise in the graduation rate in that year. All courses but Mechanical Engineering show another deviation in 2001: the rates go down again. This is also the first year that students from the Second Phase UPE curriculum enrol, but it is unclear whether there is a causal relation, as the courses at the other universities do not show this trend.

Table 2.4 | Percentages of graduation for 7 courses in disciplines of engineering education offered at Delft (TUD), Eindhoven (TUE), Twente (UT). *Source: VSNU, 2014*

Year	Comp Sc			Electrical Eng			Architect		Mech Eng			Civil Eng		Applied Physics		
	DUT	TUE	UT	DUT	TUE	UT	DUT	TUE	DUT	TUE	UT	DUT	UT	DUT	TUE	UT
								UNDIVIDED MASTER LEVEL COURSEs								
95	19/40	18/33	28/42	21/47	17/44	22/52	4/48	11/50	8/49	21/56	17/56	12/49	43/59	18/49	21/61	24/51
96	21/43	12/49	22/43	21/50	10/31	14/57	7/60	8/39	9/44	24/54	12/49	19/32	52/73	14/53	27/58	26/58
97	22/40	24/39	17/43	23/47	15/36	16/52	23/70	19/47	23/56	29/56	17/50	21/33	43/72	27/52	34/59	27/54
98	24/42	19/43	13/36	39/49	21/58	7/39	43/67	8/49	31/54	21/53	13/53	32/44	33/62	36/53	19/49	27/55
99	35/45	21/37	14/36	43/57	14/46	15/42	50/63	10/50	26/46	34/66	27/60	47/60	34/60	41/53	11/56	20/52
00	43/48	23/46	24/62	44/59	15/44	10/46	43/61	39/61	29/52	32/67	10/64	54/63	13/51	44/63	48/70	27/56
01	37/57	31/43	58/65	31/50	28/34	45/57	36/56	44/58	40/63	38/52	50/55	57/64	65/76	31/49	28/55	50/69
								BACHELOR COURSES								
03	33/57	25/51	34/56	30/50	- /-	20/83	13/53	25/62	17/55	28/65	25/60	33/66	35/68	14/53	31/59	59/83
04	30/59	20/47	20/44	40/53	-/-	8/59	14/50	38/67	17/55	29/65	46/76	24/61	45/77	23/56	19/52	32/59
05	38/67	33/56	15/37	38/68	3/45	18/87	18/63	37/70	19/53	31/65	43/70	34/65	40/78	31/68	33/64	62/87
06	27/52	32/77	20/65	41/76	8/61	10/70	22/72	30/77	20/65	30/72	38/80	31/73	43/88	28/53	41/71	33/70
07	42/68	22/44	36/62	41/56	17/56	24/69	45/79	38/73	29/65	43/81	35/69	40/77	43/81	37/70	43/74	39/69
08	43/NA	49/NA	49/NA	41/NA	36/NA	9/NA	51/NA	56/NA	35/NA	54/NA	62/NA	46/NA	59/NA	40/NA	42/NA	50/NA
09	56/NA	64/NA	45/NA	53/NA	51/NA	46/NA	66/NA	66/NA	36/NA	62/NA	51/NA	55/NA	60/NA	42/NA	66/NA	69/NA

Note: Undivided master courses: after 6 years (nominal duration of the course +1 year) and after 8 or more years after first enrolment. These percentages include students who received a bachelor diploma in their course after the period of transition between undivided and bachelor curricula was over. Bachelor courses: 4 years (nominal duration of course +1) and 6 years after first enrolment. Table only contains fulltime students with UPE background.

In conclusion the differences in graduation rates between and within courses are large over time and do not show any clear patterns of increase or decrease. The same observation should be made for Table 2.3: the ranges between the graduation percentages between courses in different universities are large, and the differences between courses within a single institution differ considerably within student cohorts. For instance, in the Delft student cohort of 1995 only 30 per cent of the students in mechanical engineering had graduated after 6 year, while in civil engineering 52 per cent had graduated.

2.2.2 | Differences between engineering and non-engineering fields in the Netherlands

Non-persistence and long-term students are not exclusive to engineering. It also occurs in other disciplines in education. Table 2.5 consists of a set of percentages for graduation for the same cohorts considered in Table 2.4 in disciplines representing some arts, humanities, social sciences and natural sciences: Dutch, English, History, Law, Economics, Psychology, Biology, Physics & Astronomy and Chemistry. These courses have a nominal duration of 4 years whereas courses in engineering take 5 years to complete.

These numbers show many similarities with the data from the engineering courses. Again, there are large differences between the years. The differences between the percentages of graduation after the nominal duration of the courses plus 1 and the percentages of graduation after the nominal duration of the courses plus 3 or more years, is considerable. In these courses the graduation rates are comparable or slightly higher than in engineering.

Most of these courses show fluctuations within the course over the years. Most of these courses have a modest upward trend in graduation rates. The students in these cohorts were affected by the same national policies, but these students were subjected to different education policies of their respective universities.

It is unclear to what factors the differences can be attributed, it could have to do with more effective teaching and learning environments, and with the different norms and values present in those universities, but there is no way to be sure.

2.3 | Differences between engineering and non-engineering

In 1998 Haghighi called for the recognition of a new research discipline: engineering education (Haghighi, 1998). In his editorial in the Journal of Engineering Education Haghighi argues that although engineering educators ask themselves questions that are very similar to questions posed by educators in the arts and humanities, their answers may not necessarily be the same, because the contexts and the challenges in these fields are very different. De Graaff (2009), however, argues that engineering education research (EER) is not a separate discipline, because if this were true, researchers would have to develop their own separate methods to define their area of research, and this has not been done.

De Graaff regards EER as an applied field of study that is situated within the discipline of educational psychology, which means that the established methods of educational psychology are available to, and viable for researchers in engineering education to use. Like Haghighi, De Graaff also recognizes that student attributes, curriculum design and attributes, culture in engineering differ from those of students in non-engineering fields. These topics are discussed below.

Table 2.5 | Percentages of graduation for 9 courses in disciplines of non-engineering education at all Dutch universities offering these courses. *Source: VSNU, 2014.*

Year	Dutch	English	History	Law	Economics	Psychology	Biology	Physics & Astronomy	Chemistry
					UNDIVIDED MASTER COURSES				
95	23/46	20/35	16/40	14/46	19/58	26/59	28/56	22/54	31/58
96	21/48	24/35	15/42	16/49	18/57	29/58	28/54	11/47	33/60
97	21/46	19/28	14/44	15/49	19/58	27/59	23/57	19/49	25/53
98	20/48	19/37	13/41	15/49	21/60	27/60	26/62	17/51	22/54
99	21/49	22/40	15/53	17/53	21/57	27/64	10/55	7/50	14/53
00	31/44	28/46	25/52	21/51	24/59	30/65	23/59	9/43	27/61
01	41/53	43/52	34/52	28/53	30/55	44/69	30/65	16/49	32/57
					BACHELOR COURSES				
03	53/66	49/66	45/62	33/53	36/55	51/67	42/64	28/47	50/70
04	53/66	47/57	41/58	33/54	34/54	51/66	52/71	26/50	43/67
05	58/66	56/65	47/61	37/54	35/53	56/71	46/65	37/55	42/62
06	53/65	54/66	45/62	38/54	35/51	54/70	46/64	40/55	44/66
07	58/66	50/57	43/58	38/53	37/51	56/69	57/68	36/53	50/63
08	51/NA	51/NA	50/NA	46/NA	43/NA	60/NA	59/NA	34/NA	49/NA
09	58/NA	50/NA	50/NA	46/NA	43/NA	61/NA	57/NA	40/NA	47/NA

Note: Undivided master course: 5 years (nominal duration of the course +1 years) and 6 or more years after first enrolment. Bachelor courses: 4 years (nominal duration of course +1) and 6 years after first enrolment. This table only contains fulltime students enrolled based on a UPE diploma.

The natural sciences, technology, engineering and maths are related disciplines and are often grouped using the acronym 'STEM'. This acronym has been in use in the USA for some time and was introduced to address the idea that these disciplines should not be treated as isolated units (Wikipedia, 2014). There are other acronyms used to indicate roughly the same fields, such as MINT: maths, information science, natural sciences and technology and SME, sciences, maths and engineering. In this dissertation the acronym STEM is used. We use the term 'non-STEM' to indicate arts, humanities and social sciences, including economics and business studies. At DUT the 14 engineering bachelor courses comprise all four disciplines of STEM. In some cases we use the terms engineering and non-engineering. We use these terms when studies deal only with engineering education. When specific research studies are discussed in this dissertation, the acronyms and terms used by the authors of the studies being discussed are employed.

2.3.1 | Differences in cultures

The idea that contexts and challenges across academic fields are different is not new. Becher (1994) grouped disciplines based on the nature of knowledge they seek and of disciplinary culture. The nature of knowledge generated in engineering and technology is about know-how knowledge and it is purposive, it is concerned with mastery of the physical environment and results in products and techniques. The nature of disciplinary culture is entrepreneurial and dominated by professional values. The pure sciences which are cumulative in nature and which are concerned with universals, quantities and simplifications result in discovery and explanation. The culture of the pure sciences is marked by task-orientation, competition and a high publication rate. On the other side of the spectrum are the humanities and pure and applied social sciences. The humanities and pure social sciences are reiterative in nature and result in understanding and interpretation, while the applied social sciences are utilitarian in nature and result in enhancement of professional practice. Their cultures are individualistic and pluralistic, and are loosely structured. Becher (1994) argues, based on these differences, that education consultants and policymakers need to be firmly aware of these two elements in which disciplines differ and consider this before coming up with uniform measures. Umbach (2007) argues that the phenomenon of culture is slightly more complex than Becher suggests and adds that university staff also represent subcultures that overlap to some extent with the disciplinary cultures. Institutions also have separate subcultures that may overlap with disciplinary cultures. These three subcultures feed into attitudes towards pedagogies, the number and kinds of interactions teachers have with their students and what kinds of classroom experiences they emphasize. Ultimately this synergy shapes a student's experience of learning and engagement. Lindblom-Ylänne, Trigwell, Nevgi and Ashwin (2006) confirm this idea in their study on the effects of discipline and teaching context on approaches to teaching, and Smart (2010) and Smart, Ethington, Umbach and Rocconi (2009) confirm this idea in their studies on the effects of consistency between students' personality types and the academic environment on learning outcomes. Lattuca, Terenzini, Harper and Yin (2010) add to this complexity by adding the layer of personality to how we understand disciplines. They did a large-scale survey to study the correspondence between personality types and environments in engineering schools in the USA based on Holland's person-environment theory on career choice and they argued that: "*faculty members' responses to proposed or actual changes within a single organisational unit,* *such as a school of engineering, will vary systematically by academic specialisation because these specialisation areas are distinctive environments dominated by particular personality types.*" (Lattuca et al., 2010, p. 23). The researchers found that departments with similar personality and environment types had responded significantly differently to the 1997 edition of standards for education set by the accreditation board of engineering and technology (ABET), which added 11 new student learning outcomes, including the need for active learning. For instance departments of the "enterprising" type, typically industrial engineering, were more likely to respond to the call for active learning than mechanical engineers or physicists who were considered typical examples of the 'realistic' and 'investigative' types. The authors postulate that their findings support the idea that ignoring these differences among subfields may result in under-, or overestimating, faculty members' willingness to accept undergraduate education reforms.

This notion of distinct differences in cultures between the disciplines and sub disciplines substantiates the approach taken in this research that engineering education needs to be approached differently if the research is meant to have an impact on the field.

Delft University of Technology tends to discern between three 'boxes' that represent the sub disciplines present in the university when it concerns financial matters. The science box comprises the faculties of applied sciences and electrical engineering, mathematics, and computer science. The engineering box comprises the faculties of civil engineering and geosciences, mechanical, maritime and materials engineering and aerospace engineering. The design box consists of the faculties of architecture, industrial design engineering and technology, policy and management. DUT leaves most of its policy development to the faculties, as will be discussed further in section 2.4.

2.3.2 | Differences in curriculum design

Designing any curriculum starts with defining the overarching learning goals of the curriculum and those of its smaller units of learning. ABET has drawn up a list of final objectives for engineering courses. These objectives include in depth knowledge of essential academic disciplines such as advanced mathematics and mechanics, but also require a graduate to have the ability to grasp complex engineering problems and to apply academic knowledge to make complex designs that take into account multiple issues such as sustainability, financial limitations, and social and ethical considerations (ABET, 2014). An engineer also needs skills to design and communicate the essentials of those designs to others who may or may not be technically skilled. This component of 'design' is what sets engineering apart from the sciences. Van Peursen (1969) illustrates the differences between formal sciences, empiric sciences and the applied sciences. The formal sciences such as mathematics and logic in Van Peursen's model gather data on the reality surrounding us and based on this give us the instruments needed for empiric sciences such a physics and psychology. The empirical sciences in turn use the methods of the formal sciences and supply theories and data to the applied sciences, which in turn apply the knowledge acquired. This supports the idea that there is a distinct difference between sciences and engineering: the sciences study phenomena in nature and come up with theories that are applied in the design of solutions to complex problems by engineers.

Students in engineering have a lot of ground to cover: they need to study the sciences, but they also need to learn how to transfer the theories into feasible designs and they need to become engineering professionals (Borrego & Bernhard, 2011). This is one of the reasons why engineering curricula are overloaded (Van den Berg, 2002; Seymour and Hewitt, 1997; Sheppard et al., 2009). In 1993 a fifth year of study was added to the engineering curricula in the Netherlands to make the curriculum more comparable to other European engineering curricula. This fifth year is filled with coursework intended to help students to become more skilled in applying the basic engineering skills and, importantly, the new features in engineering education that are now found to be essential, like understanding components of communication, team work, sustainability and ethics are taught and practiced.

An engineering curriculum typically consists of lectures on academic subjects and a wide range of participatory learning activities that can include lab work for experiments, design projects working in teams, academic tutorial sessions and tutorials in skill development such as communication and presentation skills, drawing skills, learning to use machinery for manufacturing processes and so on. Engineering students take many courses and spend many hours in school compared to students in non-STEM fields (Ohland et al., 2008; Seymour and Hewitt, 1997; Sheppard et al., 2009). Sheppard et al. (2009) observe that engineering curricula are overloaded and strongly scaffolded, meaning that subjects build on knowledge taught in previous subjects, which makes it difficult to make up for delays once a student has become delayed. The authors also note that teachers in engineering often feel very strongly that their subject is of utmost importance as to whether or not a student will become an excellent engineer. In addition, the students still have to work on their assignments and independent study. Curricula in arts, humanities and social sciences usually require attendance at fewer courses, with fewer practical sessions and include more independent course work (Jansen, 1996).

2.3.3 | Differences in student attributes

In the previous section the work of Lattuca et al. (2010) was introduced. They demonstrated that personality is an important factor in the work environments people choose and in which they are comfortable. Based on this, it can be assumed that individual students tend to choose disciplines, and later occupations, consistent with their motivations, knowledge, personality and abilities, and once in a field they are supported and rewarded for these attitudes and resulting behaviours. The way individuals respond in a situation can be considered to be a function of their situation and a function of their behavioural repertoires, their distinctive patterns of interest, competencies and the preferred activities associated with their personality type (Lattuca et al., 2010). Lattuca et al. (2010) established that different personality types correspond with different fields of engineering. Individual student attributes make one career more likely than another. Seymour and Hewitt (1997) also observed this process of self-selection of students based on attitude, motivation and preferences that resulted in a population of science, maths and engineering (SME) students with different attributes to those of students on non-SME courses. This self-selection was based on the subject of a course, the differences in the contents of courses, the different skillsets required of students to be successful in a field and the skillsets required of the students at the end of the course, the perceived difficulty of the discipline in question and the kinds of teaching and learning activities common in a particular academic field.

Motivation is an important predictor of university success (e.g. Pascarella & Terenzini, 2005; Pintrich & Schunk, 1996). Success starts with a motivation to study a particular topic. The decision to enrol in a course reflects a process of self selection: students who are not interested in a topic or who believe they are not up to it, for whatever reason, will probably not enrol in a course on that topic. The Dutch national platform for science and technology (Platform Bèta Techniek) commissioned a study into student motivations to pursue degrees in science and technology (Betamentality.nl, 2009). The researchers claimed that latent personality dimensions in youth reflect how persons relate to technology to some extent. The researchers discerned between four dimensions pertaining to youngsters' attitude to technology: 1) intrinsic motivation or interest in technology, 2) focus on/ frustration with teaching methods in secondary school, 3) expectations of sciences, technology, engineering and maths leading to dull work and 4) focus on status/ extrinsic motivation. Students who choose STEM disciplines score differently on dimensions 1 and 3 compared to students who opt for non-STEM disciplines. Students who enrol in sciences, technology, engineering and maths courses were found to have different profiles based on these dimensions. In turn this means that students still may have different attitudes to their courses when they enrol. This is discussed in more depth in chapter 3.

Korpershoek, Kuyper, Van der Werf and Bosker (2010) studied differences in scores on the 'Big Five' personality traits, i.e. openness, conscientiousness, extraversion, agree-ableness and neuroticism, between secondary school students who opted for the science and technology profile and found that the students who chose this profile scored significantly lower on extraversion, but higher on conscientiousness. Graziano, Habashi, Evangelou and Ngambeki (2012) studied differences between students in engineering and psychology. The researchers looked into two dimensions of personality that underlie the Big Five. These dimensions are Person Orientation (PO) and Thing Orientation (TO). PO and TO reflect how people relate to people and physical things in their environment. PO and TO were found to be independent, or unrelated, dimensions of personality (Graziano, Habashi, & Woodcock, 2011; Woodcock et al., 2012). The researchers established a relation between the extent to which a person is person oriented and thing oriented and their choice of academic field. Students in engineering scored significantly higher on TO than students in other fields. For non-STEM students there were significant differences between male and female students in their scores on TO and PO, but these differences were not found for students in STEM courses. First year STEM students were asked if they were planning to persist in engineering and the students who stated this intention, scored significantly higher on TO than the students were intending to leave engineering or who were undecided about their courses.

2.3.4 | Reflection on differences between engineering and non-engineering

This section started out with a quote from Haghighi (1998) who made a case for engineering education as a separate discipline within education research. Becher (1994) made a similar case to recognize differences across academic disciplines based on the nature of knowledge that is pursued and the nature of the culture in the discipline. Many other researchers have found cultural differences across disciplines and they make a compelling case for being very careful when treating higher education as a single field of research. Differently set up curricula are a result of the differences in the nature of the knowledge required, the culture and the standards active in a particular field of learning. Engineering is a field that trains students for a profession and partly as a result, the discipline and curriculum is dominated by professional values. As postulated by Lattuca et al. (2010) personality types within engineering differ and it is safe to assume that there are differences in personality types between students who opt for science, technology, engineering and maths courses and those students who do not. This is supported by the research of Graziano et al. (2012) who found that engineering and non-engineering students have different profiles in terms of person- and thing orientation. These differences are related, but altogether it makes a strong case to treat engineering and non-engineering fields as separate contexts of study

2.4 | Research into student success in Delft University of Technology

2.4.1 | Studies on student success

Within DUT a lot of attention has been paid to student success, but not in terms of comprehensive research. We managed to retrace two studies that specifically looked into student success in DUT. One study dates from 1959 and was briefly discussed in section 2.1.2. The board of the university had commissioned this study because they felt that the issues of attrition and delay were becoming urgent and they invited a panel of professors in psychometrics and education science to study the DUT situation. The panel established that early non-persistence was not the biggest problem. Students who left in their first or second year usually found other courses for which they were better suited. These students reported that they did not regret the years spent in Delft. The real problem occurred when students took more than two years to decide to leave. This often happened with students who lacked the ability to pass required examinations in their subjects. These students had usually given up trying to finish subjects, but had not left the university. The panel believed that these students were the real problem. In the 1949 cohort approximately 25 to 30 per cent of the students turned out to be unfit. About 10 per cent of the unfit students decided to leave quickly, meaning that 15 to 20 per cent needed some “help” in deciding to go on or to leave the university. After 5 years, 24 per cent had departed from the university without a diploma. An additional 20 per cent of the 1949 cohort reported they would have been helped if they had received support in studying and finishing their thesis. Compared to the early leavers, the late leavers did not gain anything, personally nor professionally, from the extra years they spent in Delft. The researchers found that these late leavers were usually very successful in establishing a peer network in Delft. This may have added to their procrastination over their decision to leave.

The researchers established that the students’ secondary school grades for the sciences combined with a survey on study behaviour had some predictive power for success. They noted that students could not report validly on their study behaviour before they had started their courses. In 2000 Van der Hulst and Jansen were asked to study attrition and delays in DUT once again. They included attributes of curriculum organization in their study to broaden the scope of the study, while looking only at student characteristics. Van der Hulst and Jansen (2002) looked at three engineering education courses: aerospace, mechanical engineering and electrical engineering and included student cohorts 1994 – 1997 in their study. They found evidence that variations in study progress could be partly attributed to the spread of a student’s study activities over the year, instruction characteristics and examination characteristics. These conclusions are similar to the outcomes of previous research by Jansen (1996) on curriculum organisation at a general university in the Netherlands, so these outcomes are not unique to engineering.

2.4.2 | Studies on interventions and innovations

Over the past 50 years there have been multiple studies within Delft University of Technology of interventions and innovations. These studies have been done in different departments across the university. Ultimately all of these studies have been aimed, directly or indirectly, at improving student success. From 1980 onwards DUT had its own department for education and didactics research headed by a full professor. In 1999 the focus of this department was changed to educational technology and it disappeared altogether around 2009. A number of notable studies on higher education have been done within this department, for instance that of Van Dijk (2000) who studied the effects of activating teaching in lectures on learning outcomes, Klaassen (2001) who studied the effects of the introduction of English within the university as a language of instruction and Van de Ven (1998) who studied the use of assignments to support learning using computer simulations in engineering education.

The university bureau had its own department for the collection of data for keeping track of university statistics and applied research, called Dienst Onderwijs and Onderzoek. Nowadays this department is mainly concerned with generating management information and statistical information for administrators and policy makers. In the past this department occasionally carried out small scale studies, for instance one into the reasons for leaving among non-persisters (Heeringa, 1998) and evaluations such as one for the Onderwijs Stimuleringsfonds (OSF), a DUT subsidy scheme that faculties could apply for grants to develop and innovate their education practices. Van Wijngaarden (1993) evaluated the results of 74 grants awarded by the OSF between 1987 and 1992 and that were aimed at improving the flow of students through DUT to graduation, to accelerate student selection or to improve student success on the whole. The most important conclusion of Van Wijngaarden's evaluation was that small-scale projects seemed to be the most productive. It is hard to indicate the 'lessons learned' from these 74 projects because only very few were documented. The studies done within the OSF framework were usually carried out by faculty education officers. These officers served, and still serve, as education consultants to faculty members and do applied research on educational matters mostly in the form of subject evaluations. Sometimes education officers look into the effects of interventions or innovations, for instance the faculty of Industrial Design Engineering tried to find out more about the reasons why first year students leave (Bos & Versteeg, 2003) and the faculty of Civil Engineering has studied the effects of implementing a modular curriculum in mechanics (Snippe & Wasmus, 1993; Vrijman & Wasmus, 1990; Wasmus & Wiggenraad, 1990).

The OSF grant scheme at DUT was terminated halfway through the 1990s. Other subsidy schemes followed, although these new schemes were commonly financed by the Department of Education. In 1993 and 1994 universities could apply for grants from the 'Studeerbaarheidsfonds' to improve the 'do-ability' of their courses (Technische Universiteit Delft, 2002). Between 2006 and 2009 the Platform Bètatechniek (National Platform for Science and Technology) granted 'WO Sprint' subsidies for universities of technology to help them understand how to improve student success in their institutions. Additionally, a number of other schemes existed to support officers and teachers to improve their teaching, for instance the Grassroots scheme became available in 2005 and focused on innovation of teaching through the use of ICT (De Koning, 2014; Onderwijskundig Centrum Focus, 2008). Most of the projects carried out under these schemes could be considered state of the art for the time frame they were executed, like the project at Civil Engineering.

Based on communications with officers from DUT and on evaluations there are available, we found that there are three problems with this way of financing interventions and innovations projects to improve student success.

1. Short term subsidy schemes: the assumption underneath these schemes is that faculties know best where and how to innovate and that the ideas/projects will be adopted by the faculty if they are successful. In reality, the projects almost always stopped when the subsidy was finished, even when initial results were promising.
2. Fragmentation of efforts: projects are often local to the extent that only a few people know about certain projects. This prevents the knowledge so obtained from being diffused in a way that people beyond those directly involved in the project will benefit from it. This leads to people reinventing the wheel in different places, others not learning from a faculties' previous experiences, dissemination of ideas not taking place and worst: making efforts that cancel other efforts out or create adverse effects. For instance, if there are too many different departments that ask for student participation in all kinds of surveys, often on similar topics, students stop responding to calls for participation, and an organisation no longer gets feedback from its students.
3. Lack of evaluation and documentation: in these grants the focus is on the action, not on the evaluation or even on documentation. Due to poor, or a lack of, evaluation strategies, many interventions were not assessed for effectiveness and the interventions could not be made visible and understood. This has also led to single measures intended to improve success being implemented multiple times in the same faculty without people being aware of this repetition and without people being able to make improvements based on previous experience. This lack of documentation makes it *impossible to say if the university has been doing enough of the right things to have any lasting effects on student success.*

2.4.3 | Reflection on DUT research, interventions and innovations on student success

Delft University of Technology has made of lot of effort to initiate all kinds of projects to obtain and retain successful students, be it research or interventions and innovation, none of which have led to any visible and lasting changes in student success, in spite of the many people who have been committed to this purpose over the years, and of the many state-of-the-art projects that have been implemented. In personal communications with officers from DUT, we commonly find three arguments that are used to counter this observation.

1. It may be that many projects have had positive effects that did not translate into increased retention rates, but into more engaging, meaningful and positive student and teacher experiences that cannot easily be quantified.

2. If the university had done nothing about retention, retention rates might have been even lower.
3. It may be that the university's actions simply cannot affect the student retention rates because graduation rates do not fall within the institution's sphere of influence.

These arguments cannot be proven nor disproven at this point as a result of a lack of documentation and analysis. Many questions remain unanswered and some of them will be explored in more depth in this research.

2.5 | Recent DUT university-wide interventions to increase success

In recent years DUT has implemented a number of policies that affect all the faculties. The two notable policies that have been implemented with the goal of reducing time to graduation are outlined below.

2.5.1 | The Binding Recommendation on Continuation of Studies

In the Netherlands universities are required by law to grant access to all students who comply with the basic admission requirements for the course for which they are applying. For universities of technology the requirement is a diploma from university preparatory education (UPE) with a focus on science and technology. Universities are in general not allowed to select students prior to enrolment. Instead, in the Netherlands, the first year of university studies is designated as a year in which to select students and refer them onwards if necessary. Since 1993 institutions for higher education have had the option to introduce an instrument they could use to send away students who were deemed unfit for a particular course of study, but universities have only started to implement such instruments since 2006 (Inspectie van het Onderwijs, 2010; Wartenbergh-Cras, Ribberink, & Van den Broek, 2010). Until that time selection usually came down to self-(de)selection by the students. In 2009 Delft University of Technology implemented the 'binding recommendation on continuation of study', in Dutch the 'bindend studieadvies' or in short BSA. This rule requires that all first year students must obtain at least 50 per cent of the required first year credits to be eligible to continue with the second year of their courses, i.e. 30 out of 60 European Credits. It was expected that this new rule would have major implications for the students as lack of progress would have serious consequences for students (Croese, 2008). The anticipated effects included that students would devote more time to their studies in the first year and that students who were experiencing trouble would explore other options sooner instead of pursuing a degree that might be too hard for them. In the long run this should lead to less attrition in later years and a shorter time to graduation for most students.

2.5.2 | The Bachelor-before-Master Rule

In 2010 DUT implemented the "Bachelor-before-Master Rule", in Dutch known as "Harde Knip". Until 2010 students who had not finished their bachelor course, could enrol in a master's course and take subjects. This way students would not get into trouble if they had some delays in their bachelor course: they could continue their studies and plan to take missing bachelor subjects while taking master subjects. This could lead to situations where a student would hand in her or his final year master thesis, but still had to pass a second year bachelor subject. Since the implementation of the Bachelor-before-Master rule students are no longer allowed to take master subjects if they have not yet obtained their bachelor diploma. The rule was implemented nationwide in 2012 when it was incorporated into the Higher Education and Research Act. In practice this rule means that a bachelor student who has finished all the required coursework, but still has one or two outstanding subject exams to pass, will have to wait until she or he can take that subject again before being able to enrol in a masters course. This may lead to additional delays of 6 to 12 months for students wishing to move on to master courses. Although this rule does not pertain to the first year specifically, the policy makers expect that this rule will mean fewer delays and shorter times to graduation for all students, as it is expected that students will do their utmost to prevent any unnecessary delays.

2.6 | Conclusions

The differences between engineering, sciences and arts, humanities and social sciences are subtle but real, although there do not seem to be any major differences for graduation rates in the Netherlands. Graduation rates show many fluctuations within and between courses across the board. It seems that graduation rates drop just prior to major curriculum overhauls and other interventions. The reason for this is that students who have started just before an intervention are confronted with transition arrangements and rules that often create problems of continuity for these students.

In section 2.3 it was argued that there are subtle but important differences between engineering and non-engineering teaching and learning environments, and research contexts. In addition there are major differences between national education systems and underlying cultures. These differences have implications for how we read and understand studies on student success done in different contexts, such as in STEM and non-STEM contexts, or in different education systems. It also has implications for how research on student success should be set up, for it should take account of these differences in research contexts.

Within DUT a lot of attention has been focused on interventions to improve student success, but only in rare cases have these interventions been monitored and documented. It is unclear how these interventions have influenced the retention rates for several courses in DUT. As far as we can see, no consistent effects have been found. It is impossible to establish if the interventions were focused on the right elements of the teaching and learning environment to have any effect and or if the efforts were intense enough to bring about positive change.

The most recent interventions, the BSA and the Bachelor-before-Master Rule (BMR) are mostly administrative measures and not active interventions in the teaching and learning environment. This is a different approach to student success as the student is made responsible for complying with these rules and for overcoming issues in their teaching and learning environment, rather than the university taking responsibility for creating a teaching and learning environment that is appealing and supportive to all those enrolled. The BSA is the main focus of chapter 8 where we will discuss the measure in more depth using a framework for success appropriate for the DUT context. This framework aids in understanding what element, or elements, of the teaching and learning environment in DUT should be targeted if the university is interested in increasing success. Developing such a framework was the main aim of the research reported in this thesis.

Chapter 3

Review of the literature on student success

3.1 | Methodology of literature research

For this study only publications in Dutch and English were considered. We used four strategies to find those publications that are important in the field of higher education and student success and those that are instructive for our specific research context: university STEM education in the Netherlands. The first strategy was to start out with the seminal work in the wider field in English and Dutch. Examples of seminal work in English are Tinto's Leaving College (1987) and related publications and Bean's work on the student attrition model (1982b). Examples of seminal work in Dutch include work by Van der Drift and Vos (1987), Jansen (1996), Bruinsma (2003) and Van den Berg (2002). The seminal work in STEM education is the ethnographic work of Seymour and Hewitt (1997). The second strategy was to search the archives of peer-reviewed research journals for papers on empirical student success models and theories. In searching these archives we specifically looked for papers reporting on research done in an engineering context and studies done in the Netherlands or countries with a similar education system. The third strategy was to search specific engineering education journals and archives. Engineering education research is a fairly new field of research and to date has mainly been based in the USA. We complemented this search with searches of Dutch archives on engineering education. The fourth strategy was to take the references provided in all these publications and use them to find more publications that were deemed relevant for this research. Altogether between 80 and 100 publications were considered as input for this chapter.

In this chapter we will first discuss definitions of student success and the types of models that are used in most of the research on student success. Each type of model has certain qualities and it is important to be aware of these when exploring the literature. In section 3.4 a number of studies on reasons for leaving engineering are reviewed and the outcomes serve as a basis for further exploration of the literature in section 3.5. In the final section of the chapter, section 3.6, we explore what conclusive evidence is available from our knowledge base in the field and what is still missing to understand student success in engineering.

3.2 | Defining student success

So far we have introduced several terms that are used to indicate student success and in its turn, student success can be used to indicate a variety of phenomena. In this section we look more closely at the term 'student success'.

Successful students are usually considered to be the students who enrol in university and who remain enrolled until they complete their degree. These students are 'persisters' and they are 'retained' for the institution. The American National Center for Education Statistics differentiates these terms by using retention as an institutional measure and persistence as a student measure (Hagedorn, 2005). Unsuccessful students are students who enrol and leave without a degree at some stage in the education process. Students who leave create 'attrition', a decrease of the student enrolment numbers. These students are 'non-persisters' or 'drop-outs'.

Tinto (2012) argues that practitioners in the field and researchers incorrectly assume that knowing why students leave is equivalent to knowing why students stay and succeed, as the process of leaving is not a mirror image of the process of persisting. Though the two are necessarily related, understanding the reasons students have for leaving does not automatically translate into helping students to persist. Persistence can also be taken as a process, rather than a dichotomous variable. A decision to stay or leave is never taken overnight (Seymour & Hewitt, 1997; Tinto, 1987), rather it is the outcome of a process of experiencing success or lack thereof in one or more domains of student life (Veenstra, Dey, & Herrin, 2008). In this vein we argue that success is fundamental to the process of persistence. Although success and lack thereof can be taken as a dichotomous concept, in this study it is taken as a continuous concept. Students can be more successful in one subject than in another and some students can be more successful in their course than another student. Depending on what is being studied exactly, the term 'success' can indicate different things. On the level of course graduation, success could mean obtaining a diploma, on the level of an education period, success could mean passing all or most exams, with or without considering the grades (see e.g. Hagedorn, 2005). As success is taken as a continuous variable in the research presented in this thesis, students who pass more subjects can be considered more successful than students who pass fewer subjects. When we want to understand which and why students persist or not, we need to understand which students are successful, when they are successful and in which domains of their lives they are successful, and when they are not.

3.3 | Model types on student success

Models of student success can be categorized into 3 main groups according to Bean (1982a). The categories are 1) generic descriptive models, 2) descriptive models based solely on student characteristics and 3) longitudinal process models. We will not discuss the second category of student characteristic models: these models do not aid in increasing our understanding of student success in university as they are mainly intended to devise strategies for admission rather than retention. Therefore such models were disregarded in this research. An attribute of descriptive studies is that, although they are rooted in theories and traditions, they lack a theoretical framework that explains why relationships between variables exist and why one student leaves while another one stays. Instead they provide us with insight into, and understanding of, a limited number of variables that matter to student success and how these variables are related in a specific context. The longitudinal process models describe attrition as a longitudinal process to reflect that a decision to leave is not taken overnight by a student (Seymour & Hewitt, 1997; Tinto, 1987). In sections 3.3.1 and 3.3.2 we will discuss examples of descriptive and longitudinal models as categorized by Bean (1982a) as an introduction to the outcomes of research into student success, which is discussed in section 3.4.

3.3.1 | Descriptive models on student success

Bean (1982a) categorized models of student success into various categories. In this subsection we discuss two of these categories: first descriptive models, and next longitudinal process models. We discuss them using examples from the knowledge base on student success.

3.3.1.1 | Jansen and Bruinsma's model of achievement

Jansen and Bruinsma (2005) are interested in the relationship between students' pre entry characteristics, students' perceptions of their learning environment, study behaviour and students' achievement. These variables are selected from work by Tinto (1975, 1987) on student integration and by Berger and Milem (1999) who studied student involvement and behaviour in relation to success. Jansen and Bruinsma collected data from nearly 300 first year arts students at the University of Groningen in the Netherlands in 1999 and 2000, and ran a path analysis using the fairly simple model shown in Figure 3.1.

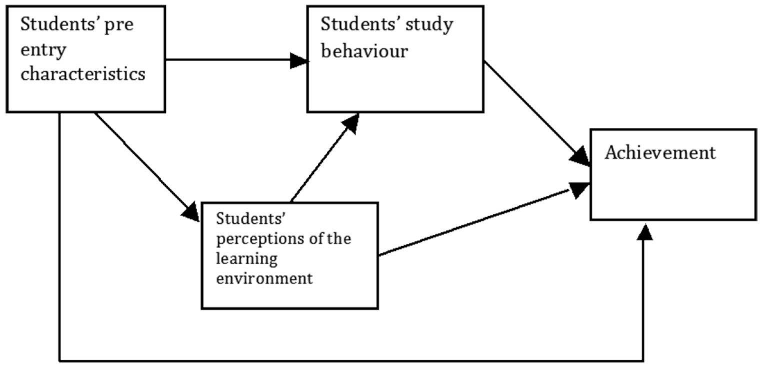

Figure 3.1 | Jansen and Bruinsma's model of achievement. *Source: Jansen & Bruinsma, 2005.*

Jansen and Bruinsma chose to operationalize achievement as first-year grade-point average (GPA) because it indicates both students passing a test and their level of achievement. The authors found that students with a higher GPA in university preparatory education (UPE), women, students with higher beginning-of-the-year work discipline, students who attend classes more often and do their assignments on time and students with greater end-of-the-year work discipline obtain higher grades in courses. The authors also find moderate correlations between aptitude and involvement and aptitude and work discipline, between involvement and work discipline and between ratings of the instructor/course and student involvement. The path model shows a good fit and explains 54 per cent of the variance in GPA seen in this cohort of Groningen art students.

In their concluding remarks, Jansen and Bruinsma add that students who reported they perceived the course to be less difficult were more satisfied with the course/instructor. A striking finding was that satisfaction with the course/instructor had a negative effect on a student's achievement. Students who rated the course/instructor positively were more involved in the course but had lower work discipline. Another finding on the rating outcomes was that those students who evaluated the course content and the assignments as difficult, attended lectures more frequently and completed their assignments on time more often. These students used more strategies that represented deep information processing behaviours. Deep information processing behaviour, however, did not correlate with achievement. End-of-the-year work discipline showed to have a large effect on achievement. This is not surprising because time spent on task and regular study have been found to affect achievement (see e.g. Carroll, 1963).

3.3.1.2 | Lackey, Lackey, Grady and Davis' study to predict academic success of first year engineering students

Lackey, Lackey, Grady and Davis (2003) base their study on observations of teaching practice at a competitive private regional university in Georgia. The authors observed that students who did well on a certain notebook keeping assignment consistently also seemed to persist and do well in their engineering subjects. This notebook keeping assignment was part of a first year mandatory prerequisite course for students who aspired to enrol in their university's school of engineering. As notebooks cannot be created overnight, good grades in this assignment are taken to represent a student's engagement, attitude, initiative, time management skills, study habits, and willingness to persevere. Good grades in this assignment are also deemed to represent the willingness of a student to invest time in learning. These attributes, associated with obtaining a good notebook grade, did not focus on grasping mathematical or scientific principles, i.e., intellectual attributes, but rather on a student's willingness and ability to pay consistent attention to course material. Data on 109 students was collected in 6 teaching sessions over three years. Data indicated that once students were admitted to the engineering course, i.e. the student had met the admittance criteria, the score a student obtained for the notebook keeping exercises during the pre engineering course was a good predictor of academic success, as measured by GPA, for first year engineering students.

3.3.1.3 | Conclusions regarding descriptive models

These two studies fit Bean's (1982a) description of descriptive models well. These studies are informative and insightful: they report on simple models that explore relationships between a small number of variables. The Jansen and Bruinsma (2005) model is rooted in theory, while the study by Lackey, Lackey, Grady and Davis (2003) is based on observations in practice. Both studies consider a limited number of variables while overall the number of variables pertaining to aspects of success is infinite. Neither of the studies explain why the variables included are related the way they are, however, these studies do contribute to a better understanding of the phenomenon of student success or to a theory thereof.

Another issue with these studies is that they were executed using small samples of cross sectional data collected in a single institution. Bean (1990) postulates that cross sectional studies are prone to a number of errors:

- research sites have limitations and restrictions that may or may not be known to the researcher,
- variables that are important to subgroups may not surface in the wider population,
- one-time events may have a large impact on the data collected,
- measurement error,
- random error and

- the complexity of the outcomes that may lead to decision makers misunderstanding and/or not acting in accordance.

Ultimately, these studies create a fragmented body of knowledge with gaps and few reference points for increasing student success in other contexts. What we can learn from these studies is that some variables show consistent effects in many studies, while other variables sometimes have an effect and sometimes not. Longitudinal models are usually taken as a more elaborate approach to model student success. These models are derived from theory and allow for more complexity.

3.3.2 | Longitudinal process models of student success

In section 3.3 two types of models as categorized by Bean (1982a) are discussed. In this subsection we discuss longitudinal process models.

3.3.2.1 | Tinto's student integration model

Tinto (1987) created a theoretical, longitudinal process model that describes the interaction between students and institutions over time. Tinto's model has achieved near paradigmatic status, as it is the theoretical framework used most often in this field (Braxton, Milem, & Sullivan, 2000). Tinto's model for student integration (Tinto & Cullen, 1973; Tinto, 1975, 1987) is rooted in work by Spady (1970, 1971). Tinto moves away from the assumption that a person's departure from a system cannot be attributed to individual characteristics: there is no such thing as a "departure prone" personality. Instead, Tinto states that the social setting of the institution is a major factor in the withdrawal process.

Tinto discerns between academic and social subsystems in institutions for higher education, each with its own characteristic formal and informal structures. The academic subsystem is mostly concerned with the academic affairs of a college or university and the formal education of students. The social system in an institution centres on the daily life and personal needs of the various members of an institution. It consists of recurring sets of interactions among students, faculty and staff, which take place largely outside the academic domain of the institution. The subsystems are distinct; integration in one system does not automatically imply integration in the other system. Tinto's assumption is that the greater the integration of a student in these subsystems, the greater the likelihood that the student will persist to degree completion. Tinto recognizes that external forces can play a major role in student departure, and that sometimes what seems to be a voluntary departure may in fact be involuntary: it can be invoked by external forces that neither students nor institutions can control.

As can be seen from Figure 3.2, in Tinto's model a student's intentions and commitment to the institution occupy a central place in the model. The more committed a person is to attain her or his goals within a specific institutional context, the more likely she or he will be integrated and, ultimately, complete a degree within that institution. Tinto states that motivation for goal attainment arises from the natural tendency of individuals to maximize their interests, rather than from the, often counter-productive, fear of punishment. Tinto's model emphasizes the process of interactions among individuals within an institution. Over time these interactions account for the longitudinal process of withdrawal or disassociation, which marks the individual departure of students.

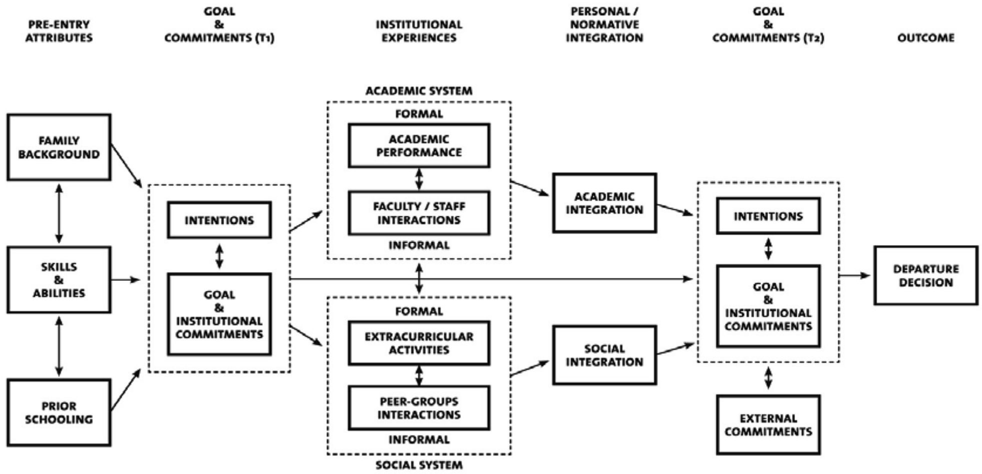

Figure 3.2 | Tinto's Student Integration Model. *Source: Tinto, 1987.*

3.3.2.2 | Beekhoven, De Jong and Van Hout's model of academic progress

Beekhoven, De Jong and Van Hout (2002) take Tinto's Student Integration Model (SIM) and added elements from rational choice theory to the model. The basic assumption in rational choice theory is people, in this case students, are likely to be rational actors who make cost benefit analyses (see e.g. Eide & Showalter, 2010). Students' experiences in their first year at university are expected to influence their actions and experiences in the second year. The same cost benefit analyses would occur when students move from the second to the third year. The researchers combine elements from both theories into a model that may be a more realistic representation of the actual process of being successful or not than SIM alone in an attempt to create a better understanding of student academic progress.

Beekhoven, De Jong and Van Hout (2002) tested their model by applying path analysis and found that, in this combined model, 80 per cent of the expected paths are significant. The significant paths are shown in Figure 3.3.

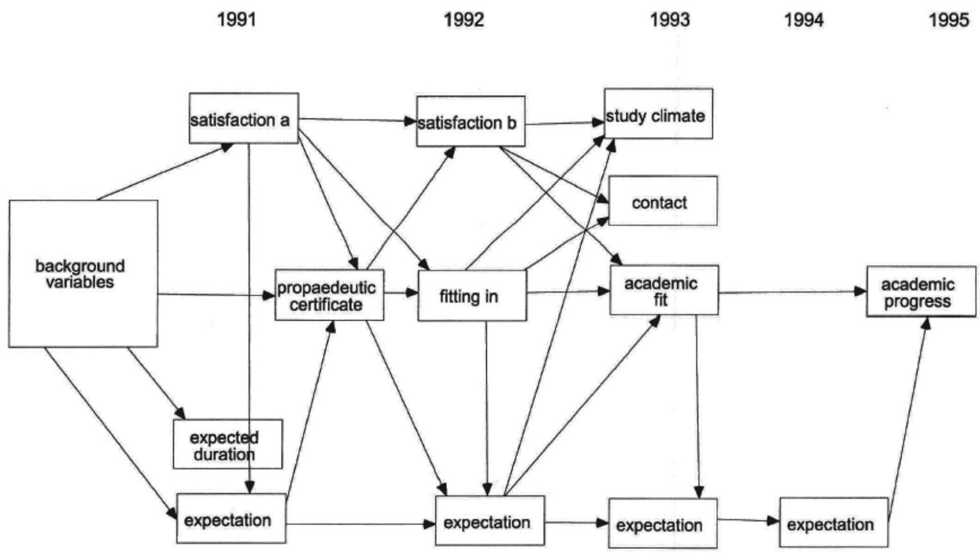

Figure 3.3 | Significant paths in the Beekhoven extended model of academic progress. The variable 'expectation' was measured four times. *Source: Beekhoven, De Jong and Van Hout, 2002.*

Generalizability is an issue across research sites as it is very difficult to measure variables in exactly the same way in different research contexts, with different populations, etc. For example Beekhoven, De Jong and Van Hout (2002) studied multiple publications based on Tinto's integration model and they found that as a result of poor definitions of 'social and academic integration', the operationalizations of these concepts were so varied that they were difficult to compare.

Longitudinal models are strongly rooted in theory. Tinto based his model on suicide theory, as in the case of suicide non-persistence people who decide to leave the communities of which they are part go through a process that may have similarities to the process students go through when they are deciding whether or not to leave university. Beekhoven, De Jong and Van Hout combine this idea of integration with rational choice theory and give the students a more active role in the process of persistence. Longitudinal models tend to do more justice to the complexities and interactions of variables pertaining to success than most other models (Bean, 1990).

Tinto (2012) argued that most of the research into success has focussed on
"theoretically appealing concepts that do not easily translate into definable courses of action. … for instance, the concept of academic and social integration. While it may be useful for theorists to know that what is now referred to as academic and social engagement has a role to play in retention, that insight does not tell practitioners, at least not directly, what they could do to enhance academic and social engagement in their institution. Though a number of

researchers have addressed the practical questions of 'what works', our knowledge of effective action remains fragmented and poorly organised." (Tinto, 2012, p. 5)

A more fundamental issue is the methodologies that are commonly used in education research. Most of the time linear models are employed, but these models are based on the assumption that the independent variables are independent, however, from a practical, and from increasingly, a scientific point of view, it is difficult to maintain that this truly is the case. Cragg (2009) for instance enters a number of interaction terms in her linear model to find that different variables influence different groups of students in unequal ways based upon a student's relative position to the institution's average SAT score and cost of attendance. Some variables are significant for some groups, but not for others. In addition, effects vary by groups, indicating that some variables impact the probability for graduation for some groups of students more than others. This is in accordance with Pascarella, Edison, Hagedorn, Nora and Terenzini (1996) who found in research on student success in the first year of college that there are significant differences in effects of independent variables on subgroups of the very large sample used in the study, whereas the effects of these independent variables hardly show for the sample as a whole. Cragg (2009) suggests that previous estimates in which the assumption is made that there is no relationship between individual and institutional characteristics may have yielded misleading results. Araque, Roldán and Salguero (2009) have studied logistic regression models for success at different faculties in a university, including a faculty of engineering, and concluded that the models look different in every faculty: the findings for each faculties could not be generalized to the wider university. Adelman (1998) argues that even within deterministic linear models that aim for predictive certainty and causal explanations there is a lot of random behaviour. It is clear from models based on other paradigms, such as chaos theory, that local dynamics in such models influence or even supersede the global dynamics and it is often not understood how this happens. This observation may be an important one, because it could imply that the ambition to devise generalizable models of student success collides with ambitions to devise success strategies that work in a specific context. Other authors take this idea of interdependency even further and suggest that student success should be viewed as a complex system, instead of a linear one (Davis & Sumara, 2006; Forsman, Linder, Moll, Fraser, & Andersson, 2014; Forsman, Mann, Linder, & Van den Bogaard, 2014; Stephens & Richey, 2011).

The descriptive and longitudinal studies have generated knowledge on the relations between aspects of student success, but this knowledge is fragmented and incomplete: multiple gaps remain and it remains unclear how outcomes from these studies can be acted upon in practice in a meaningful way. To date there have been no descriptive or longitudinal action-oriented studies on student success executed in the context of engineering education. With this study our aim was to extend our existing knowledge base on student success with a model that brings together the outcomes of the research to date, that is action-based and, importantly, that is situated in a university of technology, in this case Delft University of Technology (DUT). In this study the outcomes and insights from the research to date are used to infer a model situated in an institution for engineering education that can be used to aid those designing actions to increase student success.

3.4 | Reasons for not persisting in STEM courses

In the previous section we discussed some examples of descriptive and longitudinal models used to determine student success outside engineering education and the strengths and weaknesses of these models. There have not been any studies that look at understanding student success in engineering education from an action perspective, but there have been studies that are informative for this goal. In this section we look into reasons for students to leave STEM. This will add to our understanding of student success within the context of engineering education.

In this section research related to reasons for students leaving the STEM disciplines is analysed. The first study that is dealt with is the ethnographic work by Seymour and Hewitt (1997). The second study was a study done in the Netherlands and commissioned by the Dutch Platform of Science and Technology.

3.4.1 | Seymour and Hewitt's insights in science, maths and engineering education

The ethnographic work by Seymour and Hewitt (1997) is seminal in the field of engineering education because it is the only study that looks specifically at reasons for students to persist in engineering or to leave and because the study is based on qualitative data, an approach which allows the researchers to collect very rich data. Using this approach Seymour and Hewitt contribute to the knowledge base on STEM student success. Seymour and Hewitt focus on analysing the patterns of persistence in SME[10] in seven institutions of different types at different locations in the USA, all of them offering four-year bachelor programmes. Seymour and Hewitt reported that roughly 40 to 60 per cent of students in SME stay in their course. The other students either left or switched to another study. It is not clear whether students who terminate their registration at a university switch to other universities or leave higher education altogether. Institutions often have no way of finding out what happens to a student after they leave their institution. Seymour and Hewitt did not report on the percentages of students who terminated their registration in a university. In this study the students denoted as switchers were still enrolled in university and were able to participate in the research. Between 1990 and 1994 Seymour and Hewitt interviewed over 800 students who had stayed in science, maths or engineering or who

[10] Seymour and Hewitt use the acronym SME in their research, it is not clear why they leave out the T of technology. The research was carried out in competitive public and private research universities, so we believe that these research sites can be compared with a site such as DUT.

had switched away from their course, either to the natural sciences or to humanities, social sciences, business, and other fields generally unrelated to STEM. These students were selected based on their entry level. Only students with high entry levels were recruited, because these students were considered to be capable of completing a science, maths or engineering degree. The switchers were considered to be non-persisters in SME. These students had gone through the persistence process and came out unenrolled from SME. Their stories and experiences are a rich source of information on students' reasons for leaving. One of Seymour and Hewitt's major findings was that switchers and persisters shared many concerns regarding their education. The issues identified by Seymour and Hewitt that can be considered to be unique to the SME context are discussed below. These issues pertain to the culture of engineering, the loss of able students and reasons for switching.

3.4.1.1 | A 'weed out' tradition and a masculine culture

Seymour and Hewitt (1997) found a widespread belief that shaped the way in which recruitment and retention issues in engineering were addressed. This is the belief that an ability to understand maths and science is limited to a relatively small proportion of the population. This assumption is connected to a related belief that some, even most, student switching from SME majors is appropriate or normal. Science, maths and engineering faculties expect some fallout, even a fairly substantial rate, because those presumed to lack sufficient natural ability to continue an SME course are expected to discover their limitations, and/or their true vocation for some other discipline and leave. From this perspective, the function of the traditional weed-out system is to assist this way of thinking and to assist this process. Where SME attrition is regarded as largely inevitable or appropriate, recruitment rather than retention is seen as the appropriate way to address pipeline concerns and to make sure there is a steady flow of students into the advanced years of the course. Seymour and Hewitt also noted differences in perceptions of the nature of science between staff and students. Faculty in STEM usually share determinist and elitist beliefs like "science is just hard" and a certain proportion of the students is unable to "get it". They believed that science can only be mastered when students have sufficient background knowledge and interest and put in enough effort. Students maintain a more democratic point of view, believing it should be possible to teach in such a way that the complexities of science are clarified for students and they can score good grades with sufficient personal effort and faculty support. Non-persisters in SME feel that commitment to science would mean losing the chance to have a well-rounded, liberal education and reject the competition, curve grading and the "male-ness" of the field, which was also found by Felder, Felder, Mauney, Hamrin and Dietz (1995) and by Tonso (2007). Seymour and Hewitt found many switchers whose level of ability and application should have been sufficient, given a more encouraging learning environment for them to complete their major. Based on these findings, Seymour and Hewitt concluded that SME attrition cannot be viewed as a natural consequence of differential levels of ability; classroom climate and activities played critical roles in persisting or not. Seymour and Hewitt found that there was very little difference between institutions in the nature and level of problems reported by current and former SME majors.

SME faculty members demand early commitment from students in order to build up their skills and understanding in a linear fashion over time. This makes it hard on students to expose themselves to a broader educational experience. The students who choose the sciences are encouraged to see themselves as entering difficult and demanding majors, and those who graduate are seen as part of an elite. Students who leave SME majors tend to see themselves either as failures or defectors, depending on the degree of choice involved in their decision to leave.

3.4.1.2 | The loss of able students

Most switchers were found to have worked hard in SME classes and to have invested considerable time, money, and personal commitment in their efforts to persist. Seymour and Hewitt found that engineering switchers entered with higher verbal SAT scores than the science and maths students, but their GPA's were not found to have a significant effect on persisting, which is supported by findings of Bernold, Spurlin and Anson (2007) and of Lichtenstein, McCormick, Sheppard and Puma (2010). Seymour and Hewitt also encountered a small number of multi-talented switchers, who left because they lacked sufficient intellectual stimulation to sustain their interest in a discipline. The loss of these high ability students from science-based fields should be of particular concern. Switchers and non-switchers saw their SME courses as prone to lose students who had sufficient ability and the interest to complete the degree.

3.4.1.3 | Shared concerns for persisters and non-persisters

Seymour and Hewitt (1997) found that the average time period spent in the major before leaving it was, for engineering switchers, 2.6 years and for science and maths switchers 2.1 years. The decision to leave is not one that is easily made. Seymour and Hewitt did not find switchers and non-switchers to be two different kinds of people. These students did not differ by individual attributes of performance, attitude, or behaviour, to any degree sufficient to explain why one group left a course and the other group stayed. The authors also found the most common reasons for switching arose from a set of problems that to varying degrees were shared by switchers and non-switchers alike. What distinguished the survivors from those who left was the development of particular attitudes or coping strategies, both legitimate and collegiate. Serendipity also played a part in persistence, often in the form of intervention by a faculty member at a critical point in a student's academic or personal life. Switching decisions were never the result of a single overwhelming concern, they were always the outcome of a push and pull process over time. This process typically involved reactions to problems with SME courses, concerns about SME careers and the perceived merits of academic or career alternatives.

Seymour and Hewitt (1997) give seven concerns of switchers that were shared by between 31 and 75 per cent of non-switchers. These concerns by rank are:

1. lack or loss of interest in science
2. belief that a non-SME major holds more interest, or offers a better education
3. poor teaching by SME faculty
4. feeling overwhelmed by the pace and load of curriculum demands
5. choosing an SME major for reasons that proved inappropriate
6. inadequate departmental or institutional provisions for advising or counselling about academic, career, or personal concerns
7. inadequate high school preparation, in terms of disciplinary content or depth, conceptual grasp or study skills

Only four of the issues, which contributed to switching decisions, were not substantially shared with non-switchers. Three of these reflect underlying concerns about career prospects: that the perceived job options, or that the material rewards of SME careers are not worth the effort required to complete an SME degree; perceptions of low job satisfaction and/or unappealing lifestyles in SME careers, and that careers in non-SME fields have greater appeal. The fourth issue in this group reflects students' experiences of low grades and of curve grading in their ability to do maths and science. Criticisms of SME faculty pedagogy contributed to one-third (36%) of all switching decisions, and were the third most commonly mentioned factor in such decisions, however, complaints about poor teaching were almost universal among switchers (90%), and were the most commonly cited type of complaint among non-switchers (74%). The significance of this factor did not end there. In one way or another, concerns about SME faculty teaching, advising, assessment practices and curriculum design, pervaded all but seven of the total 23 issues Seymour and Hewitt found in their study.

3.4.2 | Other studies into engineering (non-)persistence

Warps et al. (2010) studied persistence and non-persistence in STEM disciplines in Dutch universities using a quantitative approach. They approached first-year students in STEM disciplines and asked for their participation in three surveys over the course of their first year in university. Warps et al. (2010) found that students across STEM-oriented academic fields and institutions in the Netherlands had similar reasons to leave higher education or to switch courses. Table 3.1 shows the five most important reasons for switching and leaving university for the Dutch student cohort of 2008.

Table 3.1 | Top five reasons to switch courses or leave higher education for Dutch first year students in universities for STEM for the Dutch student cohort of 2008. *Source: Warps et al., 2010*.

Switchers	Percentage
I am not (sufficiently) motivated for this course.	61
Wrong choice of field/course.	52
The programme is too heavy.	35
I have problems with how the education is offered.	20
I get insufficient support.	7
Leavers	
Wrong choice of field/course.	78
I am not (sufficiently) motivated for this course.	68
The programme is too heavy.	40
I have problems with how the education is offered.	25
Problems with transitions/ poor fit of prior education.	3

Note: In total 3,814 students, of which 1,511 enrolled in STEM returned three surveys. No significant differences were found between STEM and non-STEM students for reasons to switch or leave.

Warps et al. (2010) found that the 'leavers', those students who left higher education altogether, reported that they felt they were not yet ready to pursue a university degree. Switchers, the students who left STEM but continued to pursue a degree in higer education, reported that their most important reasons to choose another course were that their expectations were not met in the first course of choice and that they did not feel at home in the course. Reasons for choosing another course included a different teaching approach and a more positive atmosphere in the new course and/or education institution. Warps and his team asked the leavers whether or not the institution could have prevented their departure. About 25 per cent of the students believed the institution could have prevented this, but the possible measures for prevention that the students mentioned were varied and inconsistent. Warps et al. also performed a logistic regression analysis and managed to predict 50 per cent of the non-persisters correctly. The most important predictors were low commitment with the course, weak science orientation, which is supported by findings of Alpay, Ahearn, Graham and Bull (2008), and little use of open campus days and other PR activities prior to enrolment.

Another study into reasons for leaving was done by Baillie and Fitzgerald (2000) who surveyed and interviewed non-persisters from a highly selective engineering college in the UK. They reported that only a very minor proportion of the students had decided to leave because of failure. Most students left for reasons that had to do with demotivation. The three main factors for non-completion pertained to issues with the students' course, their personal situation and with the style of teaching. Issues with the course encompassed things such as: the course content was found to be too theoretical, too rich in maths and uninteresting, there was too much pressure and the course load was too high. Personal situation encompassed feelings of isolation, lack of confidence, finance, social life and the male/female ratio. Style of teaching included tutorials that were deemed not useful,and a lack of communication and support. The students were asked to detail what expectations they had that were not matched by their experience. Almost all the students reported a large gap between expectations and experience of the teaching provided. They found the classes too large and impersonal, and there was too little focus on the practical side of engineering. The students also reported a gap between the expectations they had of their lives as a student and what they experienced. They found their course too competitive and had too little time for social life altogether.

Heeringa (1998) sent out questionnaires to all 844 DUT students who withdrew from the university in the academic year of 1997/1998, of which 31 per cent left without the first year diploma. The study merely scratched the surface of the issue and the response was not representative for all non-persisters, but the outcomes were worth mentioning. Students were allowed to give multiple reasons for their departure. The top 4 answers were: change of preferences or interest (35%), level of the course (31%), personal circumstances (28%), issues with education, teachers or curriculum (23%). The reasons students provided fit in well with the findings of Seymour and Hewitt (1997), Baillie and Fitzgerald (2000) and Warps et al. (2010).

3.4.3 | Conclusions regarding reasons to leave engineering

The outcomes of the Baillie and Fitzgerald (2000) and the Warps et al. (2010) studies show many similarities with the outcomes of Seymour and Hewitt (1997). Although the concepts were operationalized in slightly different ways, the researchers seem to touch on similar concepts. It is unlikely that students leave for a single reason, often students leave for some or all of the multiple reasons listed. In the Baillie and Fitzgerald, Warps et al. and Seymour and Hewitt studies students report they feel the institutions could have done more to support them. The reasons listed by Warps et al. and Seymour and Hewitt are culminations of other processes and variables, as shown, for instance, in the studies of Jansen and Bruinsma (2005) and Lackey, Lackey, Grady and Davis (2003). In the next section we will continue to explore the knowledge base on variables pertaining to student background variables, dispositions, social environment attributes, teaching and learning environment attributes and student behaviour.

3.5 | Research findings on student success and persistence

In this section a number of studies on student success in and outside of engineering are discussed. Earlier in this chapter it was argued that studies based solely on student characteristics are not of interest for the research presented here, because these studies provide little information that can be used to understand student success and persistence. That does not mean that student related variables, whether they be behavioural, disposition or background variables are not important for student success: they affect and are affected by variables representing other domains pertaining to student success and persistence.

3.5.1 | Student background variables

Student background variables are those student related attributes that do not tend to change, such as gender, age at enrolment and socio-economic status. Student background variables often explain a large part of the variance found in studies on student success (e.g. Need & De Jong, 2001; Van den Berg & Hofman, 2005).

Two student background variables that are of special interest are aptitude and gender. As Seymour and Hewitt pointed out, in engineering there is a pervading belief that aptitude to do engineering is limited to an elite, while at the same time the SME field loses able students. Aptitude is a necessary but insufficient condition for success, as will be discussed in more depth in subsection 3.5.1.2. In many studies on student success researchers have found significant differences between men and women. Scores on variables can differ to such an extent that causal models for success of male and female students end up looking very different (e.g. Bean, 1982b). In engineering education there is special interest in the success of female students because their enrolment is low in comparison to that in other fields of higher education. Gender as a variable in success and persistence will be discussed in more depth in the following section.

3.5.1.1 | Gender

Vogt, Hocevar and Hagedorn (2014) found that women in engineering enrol with very good grades for the sciences and De Winter and Dodou (2011) found that women in Delft enrol with significantly higher final grades on UPE exams for maths and chemistry than men. Van der Hulst and Jansen (2002) found that female first-year students in certain courses in Delft University of Technology obtained more credits than their male counterparts. Van den Berg and Hofman (2005) found that in general universities women obtain more credits than men, but could not establish any effects of gender on credits obtained at Delft University of Technology. This is in accordance with Vogt (2008) and Beekhoven, De Jong and Van Hout (2003). Seymour and Hewitt (1997) report that women do not persist proportionally across all SME disciplines as a whole, but that in engineering women leave at the same rate men do. This is supported by the findings of Araque, Roldán and Saguero (2009), Besterfield-Sacre, Atman and Shuman (1997) and French, Immekus and Oakes (2005), however, Seymour and Hewitt report that women entering SME majors have higher proportionate rates of switching than men. Gender does not seem to have effects on switching away from engineering (Seymour & Hewitt, 1997).

Felder, Felder, Mauney, Hamrin and Dietz (1995) found that in engineering education there were factors at work that make it difficult for women to compete on equal footing with their male counterparts. The researchers asked students to what causes they attributed their failures. Larger percentages of women reported a lack of ability. Women cited 'personal problems' three times out of five to explain their performance in a subject. Female students reported lowering their expectations of success and a reduction in confidence over the years they studied engineering. This was in accordance with the findings of Seymour and Hewitt (1997) and Tonso (2007), and with those of Meyers, Silliman, Gedde and Ohland (2010) who studied the effects of the introduction of a mentor programme in an engineering course by looking at the level of adjustment to an engineering course as reported by the students in the programme. When they studied the differences between male and female students, they found that there were gender differences regarding students' comfort with their decision to stay in engineering, but they could not establish gender effects on predicting how well students adjusted to the demands and culture in engineering. Fox, Sonnert and Nikiforova (2009) studied programmes designed to mitigate issues for women in science and engineering. They found that the programmes which viewed these issues as relating to individual students less successful in helping female students to overcome these issues than programmes which framed these issues as relating to the existing structures in institutions. This supports the idea that the structure and culture in science and engineering are not supportive to women in these fields. Further, Meyers, Silliman, Gedde and Ohland (2010) state that gender differences remain a complex issue in engineering education. They believe that gender may be confused with academic confidence as being a central factor in adjustment to the engineering curriculum.

3.5.1.2 | Aptitude

As described by Seymour and Hewitt (1997) there is a persistent belief in engineering education that aptitude is limited to a small proportion of the students and that others are not able to 'get it'. Aptitude plays a major part in student characteristics models (see e.g. De Winter & Dodou, 2011) and it consistently has effects in studies on engineering student success (see e.g. Zhang, Anderson, Ohland, & Thorndyke, 2004). French, Immekus and Oakes (2005) followed two cohorts of undergraduate engineering students at a large Midwestern university in the USA and found that SAT scores, high school rank and gender had a significant positive effect on GPA (females had higher GPAs) and that GPA was a good predictor of continuation of engineering courses, together with student motivation. Moller-Wong and Eide (1997) had found that students who had a low risk of non-persistence in engineering tended to have a high GPA and high maths scores upon entry. Veenstra, Dey and Herrin (2008) found that excellent high school results in maths and science were the most important predictor of first year GPA in engineering, besides confidence in maths and computer abilities. Outside engineering Beekhoven, De Jong and Van Hout (2003) found that initial ability was an important predictor of first year student progress, measured as the number of credits students obtained in their first year.

Aptitude seems the most important predictor of student success, although there are a number of studies in which researchers were unable to establish predictive effects for proxies of aptitude. What is interesting is that in engineering students with good grades on their engineering classwork also leave. It is safe to assume that aptitude is a strong predictor for persistence, but not the only one. Grade performance in university is not truly a background variable as such, but success tends to create more success: DesJardins, Ahlburg and McCall (2002) found that a high cumulative first term GPA reduced the chance on stop out, when students quit with the intention reenrol at a later time, and increased the chance of timely graduation.

3.5.1.3 | Other relevant student background variables

Felder et al. (1993) found that it is possible to identify at risk students early based on student background variables and scores on Myers-Briggs type indicators. De Vries, Van den Berg, Born and De Vries (2011) used another personality model with six factors and found that conscientiousness and integrity are significant predictors of the average grade students obtained, but also of productive study behaviours. Age also affects success. Jansen and Bruinsma (2005) and Prins (1997) found that the younger the students, the better their grades. Van den Berg and Hofman (2005) found that older students left their courses more often. They assumed that older students had commonly been retained in university preparatory education and this could be a sign that they had trouble with academics before they enrolled. Beekhoven, De Jong and Van Hout (2003) found a negative effect of having been retained in a grade at some point in time. They also found indirect effects of socio-economic status (SES) on first year progress. Felder, Mohr, Dietz and Baker-Ward (1994) studied students taking a course in chemical engineering in the USA and found that rural students were academically disadvantaged compared to students from urban communities. The authors explained this partly due to lower socio-economic status and less parental support for pursuing a college degree (see also: Firmino da Costa & Teixeira Lopes, 2011), however, Bruinsma and Jansen (2007) and Van den Berg and Hofman (2005) did not find any effects of SES on non-engineering students in the Netherlands.

3.5.2 | Student dispositions

In this research disposition is taken to encompass those student-related variables that are susceptible to change over time. Examples include students' motivation, engagement, goal commitment, intentions, confidence, aspirations and expectations. Student disposition variables are influenced by variables such as student background variables, but also by variables pertaining to the social and educational environment. Disposition variables are strong predictors of persistence and progress, as is discussed in this subsection.

Bruinsma and Jansen (2007) studied a model designed to explain achievement through a number of productivity factors, such as student aptitude-attribute characteristics, instructional aspects and students' social and psychological environment. The authors concluded student motivation is an important contributor to the variance found in grades: students who believe they can do a course will receive higher grades. They also found that university teachers and departments can influence grades indirectly by empowering students in the classroom. This finding is substantiated by Georg (2009) who found, in a large quantitative study at a university in Germany, that students do not contemplate dropping out because of stress or a lack of aptitude, but primarily because of weak commitment to their course of study in general or to the specific field of study in particular. The institutional influence on the tendency to leave a course is thus modest, being limited to maintaining or improving teaching quality and broadening the scope of the teaching methods used for instruction, i.e. group projects, practicals, e-tuition, etc.

Lackey, Lackey, Grady and Davis (2003) found that non-cognitive variables like motivation played a significant role in predicting success in engineering. Burtner (2005) found that attitude at the end of the first year and confidence in maths and scientific ability were significant predictors for reenrolment in engineering.

Araque, Roldán and Salguero (2009) profiled students who dropped out of courses in the arts, humanities and computer engineering at a university in Southern Spain. They found that the logistics regression models for these disciplines were different, but certain variables appeared repeatedly in the explanation of the student attrition numbers for all of the courses. These were age at start of academic year, parental social economic status (SES), academic performance, grade point average, prior education, and, in some cases, the number of rounds needed to pass an examination. Academic performance and GPA contributed positively to persistence, just like parental SES, while age and number of rounds to pass exams attributed to non-persistence. Students with weak educational strategies and without the persistence required to achieve their aims in life showed low academic performance and had low success rates. According to the researchers this implied a high risk that students would abandon the degree. Beekhoven, De Jong and Van Hout (2003) found positive effects of academic fit, commitment to the course on first year progress. Ohland et al. (2008) and Berger and Milem (1999) found that involvement and engagement of students in their course positively affected persistence. Cabrera, Castaneda, Nora and Hengstler (1992) found that goal commitment to goals such as finishing a degree of programme of study and the intent to persist had a strong relation with continuation of studies. Researchers in the Beta Mentality study looked into motivations for young

Dutch students to opt for STEM studies or not and found that there was a large variety in reasons and motivations for choosing STEM (Betamentality.nl, 2009). The study of Warps et al. (2010) established that some of these motivations affected success more than other motivations. The students with an intrinsic motivation for STEM tended to do better than the students with orientations on status or idealism. This is also supported by finding of Alpay, Ahearn, Graham and Bull (2008).

3.5.3 | Behaviour and time on task

Sheppard, Macantangay, Colby and Sullivan (2009) report that in engineering the curricula tend to be packed and fast paced. This places a heavy course load on students that they somehow need to learn to manage. This often means students have to choose between all kinds of activities and it requires a lot of commitment and single-mindedness to stick to engineering. This overload of students in engineering was also observed by Snyder who looked into the matter at MIT in 1971 (Snyder, 1971). He found that one way students learnt to deal with the pressure was to find out how they could be successful in the course, which was not necessarily the same thing as achieving the learning goals of the course. Students tended to copy the course survival oriented behaviours from older students, which did not always lead to effective study behaviours.

Van der Drift and Vos (1987) found that students procrastinate doing their class work if they do not have to take frequent exams. Therefore students make more progress when exams are scheduled on a regular basis. They also studied how much time students in a general university in the Netherlands spend on average on their studies. They found that on average students spent 1300 hours a year, but that theoretically a number of 1700 hours would be feasible under strict conditions. Van den Berg and Hofman (2005) found that 'time on task' had a positive effect on progress and that students who spent up to 12 hours a week on paid work did not experience negative effects of this work. They also found that on average, students from DUT spent more time on their studies than students from general universities, which is supported by the outcomes of the time-writing study by the Propedeutic Evaluation Committee of Civil Engineering in DUT in 1977, who found that first year students spent around 1425 hours a year (Propaedeuse Evaluatie Kommissie, 1977). Bruinsma and Jansen (2007) also found that students' tendencies to procrastinate negatively impacted their progress. Tynjälä, Salminen, Sutela, Nuutinen and Pitkänen (2005) looked at the relationships between the characteristics of the learning environment and a student's study orientations, reproduction-directed orientation, meaning-directed orientation and achievement orientation, and study success at a university of technology in Finland. Their findings indicate students' perceptions of the learning environment were related to their study orientations, which in turn were related to study success. A deep study strategy aimed at understanding was the most important predictor of success. A surface strategy aimed at passing the test, low academic confidence and a lack of self-regulation were factors negatively related to study success. Meaning-oriented and self-regulated students using a deep strategy showed the most success, opposed to students who were externally regulated using a surface approach.

3.5.4 | Social environment attributes

Non-persistence may arise from excessive social interaction as often as it does from lack thereof. Membership of student fraternities is often thought to reduce a member's academic performance, not only because of the great deal of time taken up in social activities, but also because fraternity members are thought to be disinclined toward academic achievement (Technische Hogeschool Delft, 1959), however, a large and supportive network with likeminded peers is important for student persistence. Eggens, Van der Werf and Bosker (2007) looked at the influence of personal networks and social support on persistence, while controlling for achievement motivation, time-on-task, procrastination and confidence. Social support was not found to have any effects, but personal networks did, irrespective of what kind of network was concerned. It did not matter whether the network encompassed mainly family members, friends or both. The larger the network, the greater the likelihood of persistence. These findings are supported by Oseguera and Rhee (2009), Wilcox, Winn, and Fyvie-Gauld (2005) and Thomas (2000). Beekhoven, De Jong and Van Hout (2004) tested effects of independent living on first year student progress and found that students who lived independently reported more personal problems and spent less time on their studies. This affected their progress negatively. The students who lived independently did not experience a positive effect on integration in a social network.

Engineering education is often problem-based, project-based and or team-based. Tonso (2006) and Hsiung (2010) found that such teams are of great importance to the quality of engineering students' social environments and it has effects on their learning processes and outcomes. Ramsay, Jones and Barker (2006) established that students who were well-adjusted to university life as a whole, also reported higher levels of social companionship.

3.5.5 | Teaching and learning environment attributes

It was reported in section 3.5.2 on student dispositions that student dispositions can be influenced through the teaching and learning environment. The teaching and learning environment encompasses many aspects of how education is organised and delivered.

Jansen and Bruinsma (2005) found that perception of the instructor was negatively correlated with discipline, but positively with involvement. Vogt (2008) found that faculty distance lowered student self-efficacy, academic confidence and GPA in engineering courses. Conversely, academic confidence had a positive effect on self-efficacy, which in turn had strong positive effects on effort and critical thinking. Meyers, Silliman, Gedde and Ohland (2010) studied the effects of a mentoring programme in engineering. They found that the mentoring programme did not show a measurable student benefit, but students in the programme were more comfortable approaching older students to answer questions on everything pertaining to student life, except for issues with course requirements and course content. Szafran (2001) found evidence to support the effectiveness of mitigation programmes offered to students at risk.

In a study of students' progress at Delft University of Technology Van der Hulst and Jansen (2002) found evidence that variation in a student's study progress could be partly attributed to the spread of study activities over a year, instruction characteristics and examination characteristics. This is in accordance with the findings of Van der Drift and Vos (1987), who found in their research that was done in Leiden University that students spent approximately 32 hours on their studies in a week and that per hour of teaching activity students tended to spend two hours of independent study. This proportion changed negatively once the number of taught hours exceeded 12 hours per week. Van den Berg and Hofman (2005) tested the effects of curriculum organization and examination attributes. They found that the more subjects scheduled in one period, the less progress students made. Exam attributes did not contribute to progress in a student's studies.

Van den Berg and Hofman (2005) found that integrated curricula, e.g. based on problem based learning, led to more progress. This is supported by Olds and Miller (2004) who found that 'average' engineering students selected to take part in an integrated curriculum with a fostering learning community did significantly better than their peers and reflected that the experience had had a strong and positive effect on their college careers. Severiens and Schmidt (2008) found supporting evidence for the use of curricula founded on problem based learning in terms of student learning outcomes. Felder (1995), Felder, Felder and Dietz (1998) and Beichner et al. (2007) found evidence to support that cooperative and active teaching strategies were more effective than traditional one-way lectures in engineering. Braxton, Milem and Sullivan (2000) found that faculty classroom behaviour in general and active learning in particular constituted an empirically reliable source of influence on student social integration, institutional commitment and a student's intent to reenrol if they have left a course.

Need and De Jong (2001) wondered whether or not it mattered to student success at which university students were enrolled. They tested the effect of the study environment on progress in several universities in the Netherlands including the three Dutch universities of technology using multi-level analysis. They could attribute 95 per cent of the variance to student related factors, only 5 per cent was attributed to factors related to the study environment, whether to the university or to the course. Beekhoven, De Jong and Van

Hout (2003) performed a similar study and found that student attributes and some course attributes had different effects on the average number of credits obtained in the first year in different courses. The one significant course level variable was the average amount of time students spent on their studies, but this variable was influenced by the number of exams in a course and the number of scheduled hours: these two variables were not significant in the model itself, but the authors state that there is a relation between these variables and the time students spent studying.

Tinto (1987) postulated that rewarding interactions with faculty, inside and outside the classroom, may lead directly to enhanced intellectual development and greater intellectual integration in the academic system. It can be deduced from the research discussed above that variables pertaining to the teaching and learning environment mainly have indirect effects on student success, but that these effects should not be ruled out.

3.5.6 | Other factors

Van den Berg and Hofman (2005) were interested in the effects of the introduction of a grant system on progress in the Netherlands. This system was introduced in various forms between 1993 and 1996 and required students to obtain a certain number of credits in set periods of time. For students who did not comply with these requirements, the grant would be turned into a loan. The system is explained in more depth in Appendix 1. Van den Berg and Hofman performed a multi-level analysis using variables representing grant related factors; educational factors, i.e. course and institute factors; intake characteristics of students; paid work; and social and psychological factors. Although most variance was explained by student related factors, the grant did have a positive effect on progress.

The switch from secondary school to university can be quite overwhelming. Torenbeek, Jansen and Hofman (2011) studied the effects of the pedagogical-didactic fit between secondary education and university. They found that the better the fit, the more credits students obtained in their first year of university.

3.6 | Discussion: the need for new approaches to student success research

In this chapter we have discussed two types of models that are often used in education research and we have reviewed a fair number of studies on student success, persistence and non-persistence. So far this research has not lead to major or visible, i.e. measurable, improvements in student success, but it has yielded a lot of knowledge and understanding of this issue. One of the explanations for this is that much of the research does not focus on variables that fall within the sphere of influence of institutions. From the research reviewed in this chapter, it is clear that some student background variables have no or little effects, such as financial situation and socio-economic status. Other student background variables have relatively large effects, such as gender and aptitude; however, the predictive value of these variables is erratic and only explains a small amount of variance in student success in the long term. Student disposition variables, such as motivation, success intentions, goal orientation, etc. and student behaviour variables have more persistent effects on student success as they help a student to compensate for a lesser aptitude or other characteristics that could have detrimental effects on their success. From the literature it also seems that these two kinds of variables can be affected through interactions in the classroom. This fits well with the assessment of Tinto's model by Braxton, Sullivan and Johnson (1997) who found empirical support for only a small but important number of the propositions in the model. Put in a narrative form, these 4 propositions read: student entry-level characteristics affected the level of initial commitment to an institution. These student entry characteristics included among other variables: ability, gender, and pre-college schooling experiences, i.e. high school achievement. The initial level of student commitment to the institution influences the subsequent level of commitment to an institution. The subsequent level of institutional commitment is also positively affected by the extent of a students' integration into the communities of an institution. The greater the level of subsequent commitment to an institution, the greater the likelihood of a student persisting in college. If an institution and its teachers manage to help students integrate in their academic environment, this will lead to more success. Seymour and Hewitt (1997) found that 16 out of 23 reasons mentioned for leaving an institution pertained to elements of the teaching and learning environment. This means that the central focus of activities to increase student success should be on the classroom and the student's experiences in the classroom. This does not sit well with the findings of Need and De Jong (2001) who attributed only 5 per cent of total variance in student success to the education environment. The contrast in outcomes between these studies, need further clarification.

What is missing in the literature on student success is a knowledge base of what works in classrooms and academic communities and how interventions in these areas should be designed and implemented to lead to more student success. In other words, any further research needs to have an action perspective as well as providing data to add to our understanding of student success. It can no longer be assumed that good research will somehow automatically lead to good interventions and more success. The existing literature should serve as a basis to design strategies to fill the gap in action-oriented research on engineering education success.

From this chapter it is also clear that there are similarities between research into STEM student success and non-STEM success, however, from the benchmarking studies that compare STEM and non-STEM students on a number of variables, it is clear that there are differences in the models and predictor variables for these groups of students. This validates our claim that STEM and non-STEM education and research sites require subtly different approaches to research and interventions. Research done in one context cannot easily be generalised to the other. As the curricula in engineering have a different focus than non-engineering curricula, engineering education requires special attention in such a knowledge base.

Another gap in the research on student success to date has been a lack of complexity in the models used for such research. Increasingly it is recognized by researchers that student success is difficult to describe in linear models as many variables that pertain to success interact (Cragg, 2009; Forsman, Linder, Moll, Fraser & Andersson, 2014; Stephens & Richey, 2011). It is useful to view student success as an emerging phenomenon, meaning that many variables are related and as one variable changes, it can have effects on the entire model. The same variable can also have different effects every single time a variable or relation is changed. In other words, everything in a model can be affected by everything else, but the model will still aid in understanding reality, by showing relations and mechanisms that can be studied, for instance, by focussing on the most important or consistent interactions in the model. It also provides a lot of insight into how intricately the variables included in the model are related. This opens up possibilities for us to start understanding student success and any interventions designed to promote it. Again, such models must be based on research and the variables that have emerged from previous research in this field.

Chapter 4

Research questions and design

4.1 | Introduction

In chapter 1 we introduced our research objective: to develop a situated model that aids in understanding and explaining student success at Delft University of Technology and as such, can be used as a tool for designing educational policy. In chapter 2 we argued that DUT has implemented many policies to influence student success, but that none of these policies seems to have had any lasting effect on the graduation percentages. The model that will be developed should also aid in understanding why this is so. In this chapter we specify the research questions that need to be answered to meet our objective. The previous chapters covered a lot of ground and enable us to pose research questions that add to the body of knowledge and help DUT to understand the trends and the particulars of student success within the institution with the aim of providing meaningful input for policy. The focus of this research was on student success in the first year, as first-year student success is paramount to a student's success in later years of a course. Depending on what is being studied exactly, the term 'success' can mean different things in this context. Success goes beyond just obtaining credits, for instance many students want to have a rich student experience including plenty of social and extra-curricular activities, and so on, while others are interested in deep learning and truly understanding the topics that make up the field of science they study, finding out if the course fits their level of skills and interest and so on. Failure is often taken as a lack of success, but Tinto (2012) argues that this is not the case. Success and failure are two different matters and should be treated as such.

In chapter 2 the case of Delft University of Technology was reviewed by examining graduation rates over the past years and comparing them with graduation rates from other universities of technology and those of general universities. In section 2.2 we discussed that graduation rates in engineering are somewhat low compared to those for non-engineering courses, but it is unclear from where the differences stem. In section 2.3 it was found that most of the fluctuations in success are due to student differences (see e.g. Jansen & Bruinsma, 2005), and course environments seem to have very limited effects (see e.g. Need & De Jong, 2001), while other researchers, for instance, Seymour and Hewitt (1997) argue that courses and teachers have more influence on their students than they think. Van den Berg and Hofman (2005) report that students from DUT spend more time on their studies than students from non-engineering courses, but make less progress. In section 2.4 we established that DUT has invested a lot of time and money in its interventions to improve student success. These interventions represented a wide range of topics, such as modular education, mentoring programmes, increasing the use of information technology in the classroom, and so on. Unfortunately, few of these interventions have been documented and/or evaluated. Based on this lack of information, it is not possible to establish if the interventions have had any effects and if the university has done enough of the right things to have an effect. The graduation rates post interventions have not shown any consistent improvements that could be the result of interventions in the teaching and learning environments, however, it is possible that effects are not visible on the population level, but may be present in sub populations (see e.g. Hausknecht & Trevor, 2010; Pascarella, Edison, Hagedorn, Nora & Terenzini, 1996).

The literature review in chapter 3 also revealed that students who leave are not just students who fail, there are also plenty of able students who decide engineering is not for them. The decision to leave is not taken overnight, but rather is the outcome of a process. In addition, in vein with Tinto (1987, 2012) we postulated that failure should not be considered to be a lack of success, as students who persist share many concerns with students who leave. From section 3.4 it was clear that these concerns have to do with a lack of or loss of interest in science, wrong choice of field, and with poor teaching and high curriculum demands. In addition, we concluded that there are gaps in the literature on student success in the first year of engineering education that need to be explored before we can attempt to create a model for student success for Delft University of Technology. Most models used in the literature are quantitative, data driven, retrospective models and tend to focus on theoretically appealing variables (Tinto, 2012), rather than on how findings can be applied in practice. Therefore, the model developed for the research presented here needed to be situated in the local context, but it also needed to have an action perspective so it would be suited for use in policy practice. From the literature presented in section 3.5 we know that there are certain clusters of variables that need to be included in any model on student success. These clusters are student attributes, student dispositions and student behaviour, but we also need to understand the students' perceptions of their social environment and, most importantly, their perceptions of the teaching and learning environment. Which variables should be in those clusters and how these variables are related within the context of DUT needed to be explored in detail.

4.2 | Research questions

In this research we subscribe to the notion put forward by Prosser and Trigwell (1999) that "*students do not live in an 'objective' world but in an experienced world. The learning and teaching issue is not that of how university teachers have designed and constructed their subjects and courses, but rather how their students perceive and understand they way they have designed and structured them.*" (Prosser & Trigwell, 1999, p. 59).

To explore what variables matter to student success in DUT according to the students, we needed to collect information on how students perceive and experience their success and their environment. We use the term 'success' in the broad sense we described in chapter 3, we see success as something that can have multiple appearances, and that is fundamental to the process of persistence. Obtaining credits is just one of the aspects of being successful. From the literature review we also learned that variables pertaining to student success are rarely unrelated. Cragg (2009), for instance, found that if she added interaction terms of seemingly independent variables in her linear models, she could establish better fitting models. It is likely that many of the variables that are perceived to be of importance are related and these relations need to be part of the model, however, just adding multiple interaction variables into a model may give a better model fit, but by doing so, the model can also loose its meaning and usability. Therefore we needed to explore which variables are perceived to be of importance by the students and how they believe these variables are related. Question 1 was therefore formulated as:

1. Which variables are related to success for first year engineering students at DUT and how are these variables related?

This question was explored in Study 1, reported in chapter 5. This was an exploratory, qualitative study based on group interviews with a small number of first year students from the DUT student cohort of 2009. The outcomes were validated in Study 2, which is the subject of chapter 6. Study 2 was a qualitative study with a relatively large number of first year students from DUT student cohort 2010.

In chapter 7 a preliminary model of student success is proposed based on outcomes of Studies 1 and 2 and the literature review. This model is very rich as a result of the qualitative process that was used to design it. For this model to be meaningful in practice, it needed to be reduced, i.e. a path model that allows us to explore a series of dependence relationships between variables that can be independent and dependent in a sequence of variables, where the model's output variable is represented by a numerical proxy for success. This will allow us to test the measurable effects of these variables in the wider population of DUT first year students. Relationships that could not be established for the wider population were removed from the model. The second question posed in this research was:

2. Which relations between independent and dependent variables in the model can be established for the population of first year DUT students?

From the literature review in chapter 3 we learnt that models based on the averages of the wider population do not necessarily represent sub populations of that population accurately. This observation has consequences for the usability of a model to inform policy, as it could potentially mean that policy should be targeted on specific groups of students with specific attributes. From the exploration of differences between STEM and non-STEM it became clear that there are considerable differences within the engineering disciplines and fields. These differences are recognised by DUT using 'box' categorisations of faculties into Science, Engineering and Design. This recognition called for an exploration of whether the differences are also found when the model is tested and compared across the different groups of students. The third question we posed, was:

3. What are the differences, if any, which can be established between students from the Science, Engineering and Design courses in the reduced model?

Questions 2 and 3 form the subject of Study 3, which is presented in chapter 7.

The research reported here was set up from an action perspective and the reduced model developed in this research should help in understanding possible effects of policies pertaining to student success. Therefore we applied the model ex post facto to several policy measures introduced at DUT with the intention of increasing student success. The fourth question posed for this research was:

4. How, and to what extent, will application of the reduced model facilitate our understanding of the outcomes of policy measures intended to increase student success at DUT?

This question forms the subject of chapter 8 and Study 4.

The research design consisting of the literature review and the four studies is introduced briefly below, together with the theory underlying these studies. Narratives and perceptions play a major role in these studies as Studies 1 and 2, and to a lesser extent Study 3, are based on the collection and interpretation of perceptual data from students, Studies 1 and 2 rely also on narrative data. The topics of narratives and student perceptions in research are discussed in section 4.4, together with a topic that underlies the concept of success, the theory of attribution of success.

4.3 | Research design

The research presented here consists of a literature review and four studies. The first and second studies were qualitative, the third study was quantitative and the fourth was an ex post facto case study based on documents and interviews. These studies were used to provide answers to the four sub research questions. In Table 4.1 we show which questions were answered by which studie(s).

Table 4.1 | Scheme of research questions.

	Research question	Study 1 (Qual)	Study 2 (Qual)	Study 3 (Quant)	Study 4 (Qual)
1	Which variables are related to success for first year engineering students at DUT and how are these variables related?	X	X		
2	Which relations between independent and dependent variables in the model can be established for the population of first year DUT students?			X	
3	What are the differences, if any, which can be established between students from the Science, Engineering and Design courses in the reduced model?			X	
4	How, and to what extent, will application of the reduced model facilitate our understanding of the outcomes of policy measures intended to increase student success at DUT?				X

4.4 | Narratives, attribution and perceptions

4.4.1 | Narratives in research

As stated above, the research presented here was based on the notion that students do not live in an 'objective' world, but in an experienced one (Prosser & Trigwell, 1999). Experiences can be seen as transactions between individuals and their environment and as a result students in the same learning environment can experience that environment in very different ways (Clandinin & Rosiek, 2007). Just studying the physical and social worlds that individuals operate in, will not give information on the experiences these individuals have. People organise their experiences and their memories of things that happened to them, mainly in the form of narratives: stories, excuses, myths, reasons for doing or not doing, and so on (Bruner, 1991). To unlock these experiences and create an understanding of, in our case student success, researchers should study the narratives of individuals who deal with issues of success or lack thereof on a regular basis.

Miles and Huberman (1994) view narrative research as part of the social anthropological tradition. In this tradition researchers do fieldwork, trying to stay close to the reality, experiences and narratives, of the members of a certain community. The prime analytic task of researchers is to "*uncover and explicate the ways in which people in particular settings come to understand, account for, take action and otherwise manage their day-to-day situation.*" (Miles & Huberman, 1994, p. 8) This uncovering and making explicit is typically based on successive data collection, such as interviews, which are reviewed analytically to guide the next move, either in the field or with regards to formulating or refining theories or frameworks. Narratives are not generated by logical and scientific procedures that can be falsified; narratives can at best have 'verisimilitude': a semblance to reality (Bruner, 1991) or 'degree of truth-value' (Popper, 2010). This raises issues of reliability, validity and generalizability. Creswell (2009) and Weiss (1994) argue that qualitative validity pertains to researchers checking the accuracy of their findings employing certain procedures for data collection, processing and reporting, while qualitative reliability indicates that researchers' approaches are consistent within their projects, but that the information gathered in interviews is context bound. The procedures used in this research to strengthen the validity are reported below in the descriptions on the studies. Generalizability is not a major concern in qualitative research, as the focus of such research is on the particular, in our case the particular setting of DUT.

In this study first year engineering students were taken as a specific community consisting of persons who needed to learn to understand their new environment and to learn what actions they should take on a day-to-day basis to navigate in this new environment and become successful. To uncover how the community of students evaluated and narrated their experiences in their university environment, which elements consistently played a role in these stories and how these elements were related in these stories, the study was built on exploratory group interviews using stimulus objects to facilitate students sharing their stories and entering into dialogue with each other and with the researcher.

4.4.2 | Attribution of success

Students perceive and interpret the causes of their successes or failures differently (Pintrich & Schunk, 1996). When students believe that their academic achievement depends on controllable factors, they are more motivated and generally achieve at higher levels than when they feel a lack of control over their own learning (Urdan & Turner, 2005). Success or failure can be attributed to four causes: aptitude, effort, luck and the difficulty of the learning task. Some people tend to associate their success with their abilities and their failures to their lack of effort. Pascarella, Edison, Hagedorn, Nora and Terenzini (1996) established that college students who attribute academic success largely to their own effort do consistently better on a range of academic performance and achievement motivation measure than their counterparts who see little connection between their own efforts and academic success.

There has been a lot of research into the effects of individual differences among students such as gender on attribution. Pintrich and Schunk (1996) report that the research is inconclusive, some researchers find differences where others do not. Pintrich and Schunk report that women in general have somewhat inaccurate and lower expectancies, perceptions, of their competence and efficacy, but it is not clear what attributions mediate this difference.

Killen (1994) established that students and teachers attributed academic success and failure to different causes. Generally, teachers are more inclined than students to attribute student success to factors within the control of students such as motivation and effective study techniques, whereas students are more likely than teachers to attribute success to factors that can be conceived to be beyond their control, such as appropriate balance between coursework and leisure and whether assignments were closely related to the subject content. Concerning failure Killen found that teachers are more inclined to attribute student failure either to factors that are student characteristics, such as a low score on an entry exam, or factors that are within the control of students such as effort. Students, however, are more likely than their teachers to attribute failure to factors under the control of the lecturers, such as a heavy course load, or to factors over which students have little control such as personal crises.

4.4.3 | Students' perceptions of the educational environment

Prosser and Trigwell (1999) postulate that students' perceptions of their learning environment affect their learning styles and outcomes. Students who perceive their learning environment as encompassing good teaching, clear goals and an emphasis on independence and who tend to employ a deep learning approach have a better understanding of course materials than students who perceive their learning environment as having an inappropriate workload and assessment and who tend to use surface approaches to learning. Marsh' seminal work in the field of student evaluations of teaching is multidimensional, reliable, relatively valid against a variety of indicators of effective teaching, primarily a function of the teacher rather than the course itself, and relatively unaffected by a variety of variables hypothesized as potential biases (Marsh, 2007). Students are able to assess their education fairly and their perceptions are therefore a valuable source of information to understand student success.

4.5 | Study 1: A qualitative inquiry into first year engineering student success

The research question that was the focus of Study 1 is: Which variables are related to success for first year engineering students at DUT and how are these variables related?

This research question was answered using a qualitative study with a small number of students from student cohort 2009. Student mentor groups were randomly selected from 4 faculties representing all the 'boxes'[11] of courses at DUT. These were Applied Physics,

[11] This concept of boxes was introduced in chapter 2: the science box contains applied maths and physics, electrical engineering and computer science, the engineering box contains mechanical, civil and aerospace engineering, the design box contains architecture, industrial design engineering and systems engineering, policy analysis and management.

Mechanical Engineering, Systems Engineering Policy Analysis and Management and Aerospace Engineering. Data was collected through group interviews that were held several times during the first year to get an overview of the students' different experiences throughout the year. We recruited mentor groups because there should already be a basic level of trust in those groups that would permit open dialogue on potentially sensitive topics, such as failure. The interviews were semi-structured, but we deliberately created many opportunities for students to share their stories. One way of doing so was to use stimulus objects (Padilla, 1999) that were intended to bring about a dialogue between the students on certain topics. In total 24 students participated in at least one interview. Over the course of the year four students left DUT and two of these could be retraced and were willing to participate in an exit telephone interview. Their opinions are reported separately.

4.6 | Study 2: A further qualitative inquiry of first year student success with student cohort 2010

The goal of this study was to corroborate the findings of the previous study within a larger sample of students, to clarify outcomes of Study 1 that remained vague and to complement Study 1 with insights we might have missed in the smaller study. We opted to scale up Study 2 to include the widest possible range of opinions present in the student population, and to have access to a larger number of potential non-persisters. After the non-persister interviews of Study 1 we felt we should include more non-persisters' perceptions and experiences to help us understand success as well as failure.

The second study encompassed a large number of bachelor courses at DUT. From the previous study we learnt that the circumstances and jargon specific to a course and faculty can be quite different across campus and that a researcher needs to be well aware of this to understand what the students talk about and to be able to ask meaningful, probing questions.

Therefore we selected multiple groups from a single course from each box and we recruited a single group from other courses to complement the dataset. The courses from which we selected multiple groups were Applied Physics (AP) from the science box, Civil Engineering (CE) from the engineering box and Architecture (Arch) from the design box. In addition, we interviewed students from electrical engineering (EE), computer science (CS), industrial design engineering (IDE), systems engineering, policy analysis and management (PAM) and applied earth sciences (AES). In total 84 students participated in at least one interview.

The research design was similar to that of Study 1. We recruited mentor groups in the first week of the academic year and interviewed students three times in their first year using group interviews and stimulus objects. The first interviews took place in the first month students were enrolled at DUT and they were devoted to exploring motivations, students' social environments and their experiences with some of their subjects and their course. The second interviews were done using the same stimulus object as that as used in Study 1. In the third interviews we mixed the groups and used a workshop format. Students were asked to collaborate and to create their own models of success. These models gave us a lot of data on how students believe the variables regarding student success are related to success and to the other variables.

In Study 2 it proved, again, to be very difficult to get in touch with students who did not persist in their course. We managed to retrace four students who participated in a telephone interview. We used a second strategy to recruit non-persisters for this research. The Career Centre at DUT offers 'studie (her)keuze[12]' workshops to students who have doubts about their choice of field or who do not want to persist in their course and are looking for other options. The Career Centre gave us opportunities to introduce our research in these workshops and ask for participation. Although a number of students agreed to participate in the research, no one responded to emails or phone calls to set up a meeting, and we will reflect further on this observation in chapter 6.

4.7 | Study 3: A model for first year engineering student success

The goal of this third study was to analyse and reduce the preliminary model for student success based on the measurable effects of these variables in the wider population and to test this reduced model with data representing sub populations in DUT. The third study was based on data collected through two online surveys sent to students from cohorts 2009 and 2010 in October 2010. For students of cohort 2009 this was a retrospective study as these students had cleared the hurdle posed by BSA and were enrolled in their second year. The students from cohort 2010 had just sat their first exams when the survey was sent out.

The survey for cohort 2009 was designed based on an extensive literature review and an analysis of the results of Study 1 and slightly adapted for cohort 2010. The survey contained some 80 questions on topics that have been associated with student success in previous work or were brought forward by the students in Studies 1 and 2. The results of the survey were combined with information from the university student database. This data concerned students' attributes, such as age and gender, and academic achievement, namely the students' number of credits obtained in the four terms. We also collected course attribute data, such as number of lecture hours, active and mandatory education hours, number of exams, and so on. This data was verified with officers from each course.

[12] 'Studie (her)keuze' literaly translates to 'study (re-)election' in English.

The overall response was 25 and 21 per cent of the populations of cohorts 2009 and 2010. These samples were representative of the DUT population in terms of gender distribution and course distribution, but not in terms of achievement: the respondents had obtained significantly more credits than the wider population. The first focus was data cleaning to remove incomplete cases and data reduction by removing variables that did not have any correlations to relevant variables. Next we tried to fit the model, which proved to be challenging because of the complexity of the model and small sample size. Study 3 is reported in chapter 7.

4.8 | Study 4: The model for first year engineering student success and intervention praxis

The research question to be answered in this study was: How, and to what extent, will application of the reduced model facilitate our understanding of the outcomes of policy measures intended to increase student success at DUT? To this end, we analysed a number of DUT interventions intended to increase student success by understanding how the intervention related to the model, and which of the outcomes could have been expected based on the application of the model.

We present this endeavour as a series of case studies in which we describe the intervention as we understand it using the model. We describe which elements of the model are relevant for each intervention and we explore how the results of the interventions relate to the model and vice versa. The cases selected were the implementation of the BSA in DUT, the implementation of modular education at Civil Engineering in the early 1990s and the recent implementation of *numerus clausus* selection prior to admission at Aerospace Engineering. This study is presented in chapter 8.

Chapter 5

Study 1: A qualitative inquiry into first year engineering student success

5.1 | Introduction

Issues of student success, student retention and progress, are present in most universities of engineering and technology. Delft University of Technology is no exception. Over the past 50 years this university has attempted to increase its degree attainment rate and to reduce the time to graduation of its students. As stated in chapter 3, a considerable number of studies have been done on this specific area of interest, however, these studies have not led to any measurable increase in student success. We therefore decided to approach the area of study in a different way: to start developing situated models with an action-perspective that should aid our understanding of what student success is and help to design meaningful system interventions.

In this study we focus on exploring the experiences and perceptions of first year engineering students at DUT to learn how these students view success in their first year and beyond, how they relate to their environment and how, in the students' perceptions, personal attributes and those of the environment are linked. This was an exploratory, qualitative study using a small group of students (24) from four DUT faculties. The students were interviewed three times during their first year.

In this chapter the context of the research and research questions of the study are discussed first, then the methodology used, followed by results. The chapter is concluded with a summary, and a description of the limitations of this study.

5.1.1 | Research context and the inception of the 'Binding Recommendation on Continuation of Studies'

As described in chapter 2, DUT implemented a 'binding recommendation on continuation of studies' or BSA, in 2009. This recommendation means that all first year students need to obtain at least 50 per cent of their required first year credits to be eligible for enrolment in the second year of their courses, i.e. 30 out of 60 European Credits. It was expected that this new rule would have major implications for the student experience as lack of progress would now have serious consequences for a student. The anticipated effects included that students would devote more time to their studies in the first year, and that students who were experiencing trouble would explore other options sooner instead of pursuing a degree that might be too hard for them. In the long run this should lead to less attrition in later years and a shorter time to graduation.

The university designed formal procedures to advise students on their progress and on their status concerning possible exclusion from registering in the second year. The procedure consisted of two formal communications of preliminary advise based on an evaluation of the students' progress at that time and a final decision as to whether or not a student would be allowed to enrol in the second year. The first student evaluations were sent out in December 2009 after the first round of exams and the second evaluation was sent in March 2010 after the second round of exams. These letters contained preliminary advise on whether a student should stop or continue or advise that a student was considered to be at risk based on the number of credits they had obtained until that moment. A final letter was sent in August 2010 with a final decision regarding whether the student could continue and enrol in the second year or not. If a student obtained 30 or more credits the student would be allowed to enrol in the second year. If a student had obtained fewer than 30 credits, they could ask for an exemption based on personal circumstances. Students with exemptions for certain courses were also required to obtain 30 credits if they wanted to enrol in the second year. In 2009 the BSA became effective for all bachelor courses at DUT, except for Aerospace Engineering. Aerospace Engineering had designed and implemented a new curriculum in September 2009 and did not want to expose students to the BSA while implementing this new curriculum. Potentially there could be issues with the implementation that might have adverse effects on a student's ability to pass the BSA threshold.

In addition to the BSA, DUT encourages students to obtain their first year diploma, the propedeutical certificate, in one year. This is referred to as "P-in-1". Although the diploma only has symbolic significance, students who obtain 60 credits in their first year are awarded this diploma in a special ceremony. The percentage of students obtaining P-in-1 lies between 10 and 35 per cent for the DUT bachelor courses (Technische Universiteit Delft, 2014).

5.1.2 | Research question

The goal of this study was to explore how students view success, to determine what barriers and catalysts they perceive as important to their own success and to understand how the formal and informal aspects of the barriers and catalysts to academic achievement are related to a student's success. This exploration was done as a first step towards producing a situated model for first year student success in Delft University of Technology.

To be able to frame the students' ideas on success, it was important to understand how students viewed the concept of 'success'. In the same vein it was of interest to learn how students viewed the BSA and the communications, and whether they perceived it as something detrimental or not. This study was explorative, and therefore the research question used to guide this study was kept broad: Which variables are related to success for first year engineering students at DUT and how are these variables related?

5.2 | Methodology

A narrative approach was chosen to answer this research question. It was decided to interview a limited number of students from different faculties three times during their first year. We chose to do interviews with groups of students drawn from four faculties at DUT. The study was executed in the academic year 2009/2010.

5.2.1 | Narrative research

According to Bruner (1991) humans organize their experience and their memories of things that happened to them, mainly in the form of narratives: stories, excuses, myths, reasons for doing or not doing, and so on. Narratives are not generated by logical and scientific procedures that can be falsified; narratives can at best have a semblance to reality. In other words, people, in our case students, cannot know reality as such but they know their version of reality, constructing stories about their experiences. In this study first year engineering students were taken to be a specific community consisting of persons who needed to learn to understand their new environment and to learn what actions they should take on a day-to-day basis to navigate in this new environment and come out successfully. To uncover how the community of students evaluated and narrated their experiences in their university environment, which elements consistently play a role in these stories and how these elements are related in these stories, this study built on exploratory group interviews using stimulus objects to facilitate dialogue about the students' stories, with each other and with the researcher.

5.2.2 | Group interviews

Groups interviews can capture the dynamic nature of group interaction and create a social context that is more natural to respondents than individual interviews (Krueger, 1994).

Respondents can react to each other's views and experiences and this generally generates the shared range of opinions that are present within the group. Extreme opinions are easier to detect, as respondents can bring up their experiences to counter opinions they do not recognize. An additional advantage of focus groups is that they enable a researcher to become simultaneously involved with more respondents and therefore to involve more reposdents and collect more possible viewpoints. A possible disadvantage of group interviews is the possibility of 'group think', a premature concurrence-seeking tendency that can occur in groups and that influences the outcomes of a group decision process. Park (2000) found that group think occurs more frequently in groups that used a highly structured process. In this study we used a semi-structured approach with no formal decision making points. We believed that this way we could get the most information out of the interviews and we could prevent 'group think'.

The groups were interviewed three times in their first year. The first interview took place in the first two weeks of the academic year, in September 2009. The second interview was scheduled for the end of the first semester, January or February 2010. The third interview took place around the time of the final round of exams in late June 2010.

The first student interview was semi-structured and touched on three topics: choice of field, first impressions of their courses and first perceptions of success. In the follow up interview the students were asked to review their experiences in the university to date using a visual technique called 'storylines' which is discussed in more depth in the next section. In the third interview the students were asked to reflect on their experiences of the first year using a storyline, a stimulus object which will be discussed in section 5.2.3, and they were asked to make an inventory of factors that they believed supported their success to a larger or lesser extent. Students were asked to write down as many factors that they believed could aid them in obtaining credits on sticky notes. Next, the students were asked to put the sticky notes on a board on which concentric circles of importance were drawn. The middle circle represented high importance to obtaining credits and the outer circles represented decreasing importance from the centre. The researcher clustered notes with similar topics while dialoguing with the students to check if the sticky notes represented elements that in the minds of the students were similar or not. The interview guides and questions used in these sessions with students are included at the end of this chapter.

5.2.3 | Stimulus objects

Stimulus objects provide participants with a visual aid that can elicit a dialogue between respondents and a session moderator and which helps to capture this dialogue (Padilla, 1999). Stimulus objects can also aid in the dialogue when sensitive subjects are brought up. The storyline technique for instance makes it less confronting for respondents to discuss potentially sensitive topics such as failure (Gergen, 1988). The storyline is a technique with strong roots in narrative research and is described in Gergen (1988) and Gergen and Gergen (1986) who use this technique to explore college students' feeling of general well-being. Often storylines are analysed as artefacts, but in this study they were merely used to elicit dialogue among students and to understand what are shared stories and what are individual stories. A storyline is a two-dimensional graphic representation that shows a person's experience (y-axis) on a time line (x-axis). In the first interviews of the research presented here the timeline ran from September 1st until the day of the interview. In the second interview the timeline started around the time of the final exams of the first semester. Students were asked to think of those events that marked their experiences of their first semester subjects and their experiences of being a student as a whole during this time, and to indicate what effects these events had had on their university experience (y-axis). There are several items of interest when discussing a storyline: events that make the line change direction, the general incline of the storyline and the general purport of the experiences. These could be items for clarification or further exploration to be discussed in the group.

The "sticky notes" technique was also used. In this technique students were asked to think of possible answers to a question and write down each answer on a sticky note. Next students were asked to stick their notes on a large piece of paper, in this case with two concentric circles used to present the perceived importance of an answer. Together with the group the facilitator of a session asked for clarification of the answers and facilitator grouped together sticky notes with similar answers. In both techniques students can, and are encouraged to, respond to each other's contributions.

5.2.3 | Sampling

Students from four faculties were selected. These faculties each represent one of the boxes that are used in DUT to cluster its subjects and teaching. The courses included in this study were Applied Physics (AP), Mechanical Engineering (ME) and Systems Engineering, Policy Analysis and Management (SEPAM). In addition students from Aerospace Engineering (AE) were recruited because these students were not exposed to the BSA at this time and it was important to capture the full range of ideas on success in the university at that time. Participation in the research was voluntary. Interviews were scheduled for break periods so they would not overlap with any education activities and lunch was provided.

Wherever possible existing student mentor groups were approached and asked to participate. These groups are assembled randomly within the various courses and served as social groups and as teams for project-based education activities. This meant that a basic level of trust is already present in those groups which was an advantage for group interviews (Krueger, 1994) and when using the narrative technique of storylines. Freely sharing stories about private experiences can be difficult if participants do not know and trust each other at a basic level (Beijaard, Van Driel, & Verloop, 1999; Gergen, 1988). The researcher scheduled a time with the mentor to introduce the research to the students and ask for their participation. Students were provided with a letter with information on the research and a consent form. These are included in Appendix 2. With the students from SEPAM it turned out to be impossible to set up a meeting early in the academic year, as a result their first interview took place at the end of the first semester.

In Applied Physics the mentor groups did not serve as project groups and it was not possible to approach groups as such. Instead, an administrator of the course randomly selected students and approached them to ask if they were willing to participate in the research. This procedure took a fair amount of time and the first interview for this group was therefore scheduled for February 2010.

In total 4 students from AP, 6 students from SEPAM, 7 students from ME and 7 students from AE participated. Not all the participants attended all the sessions, but all sessions were attended by at least two students. In some cases separate interviews were planned to accommodate students as much as possible. In this study all names have been changed to ensure the anonymity of participants.

5.2.4 | Coding

All the interviews were transcribed verbatim and analysed using the Atlas TI software package. A codebook was created in an iterative process. First all the transcripts were read carefully and coded using the generic codes proposed by Miles and Huberman (1994, p. 61). All transcripts were recoded using codes that referred to the setting the students related to. These settings included, for instance, social settings in the course or at a student fraternity, and formal or informal education settings. These 'setting codes' were delineated based on the literature review and on a first reading of the transcripts. Next, using the 'open coding'-technique codes were developed to diverge within the overarching setting codes. These open codes were revised and combined until there was a single consistent set of codes. This process was done by the principal researcher and by a research assistant. The principal researcher did the subsequent coding of the documents. In using this converging and diverging strategy we aimed to prevent bias that can occur when developing code using the 'open coding'-method only. Certain fragments pertained to several codes. In such cases all the codes that applied were assigned to the specific fragment. The point of departure was that fragments should preferably have a single code, but multiple codes up to three were considered acceptable. As a result, it is possible that some fragments deemed to have reference in more than one area, may be quoted under different headings in the results section below.

5.3 | Results

In this section all the direct quotes are indicated in italics. Sometimes quotes are paraphrased. All quotes are used anonymously: the names starting with an H refer to students from Applied Physics, the names starting with a P refer to students from SEPAM, the names starting with an M refer to students from Mechanical Engineering and the names starting with an A refer to students from Aerospace Engineering.

5.3.1 | Success intentions

Students were asked about their success intentions for the first year and for later years in all three interviews. Success intention was taken as intention to pass all 60 credits of the first year in one year, also referred to as a P-in-1. Students were also asked how they perceived the requirement to obtain at least 30 credits in their first year, if they expected to be allowed to enrol in the second year, and how they perceived non-persistence. Three general categories of success intention were identified.

1. P-in-1 as a beacon: several students stated that the P-in-1 is a beacon, a higher goal. They strived for it, but they did not not care much if they would not make it. There were two lines of underlying argumentation for this thought: One, it cannot be done anyway. Harald said that this belief that it cannot be done permeated all levels of the university. At AP all the first year students met with and academic staff member a number of times in their first year and Harald felt this person tried to temper his ambition, although Harald had passed all his courses with high grades. Two, students did not know if this level of achievement would be for them. Andrew said in the first interview that he would start setting clear goals after the first round exams, not before.
2. A P-in-1: so what!? Andrew stated that he felt passing the tests was less important than understanding the coursework. Matt was committed to becoming a mechanical engineer, but he preferred to take his time rather than rush through the courses. If that meant that he would take 6 years or slightly more to complete his course that was fine. The P-in-1 could still serve as a beacon for these students.
3. A P-in-1: go for it! Some students felt that, since they needed to pass these first year courses anyway, they preferred to get it over with. Some students had other motivations to want to pass the first year. To obtain a teaching assistantship and certain student association board positions or academic board positions a student needs to have obtained the first year diploma.

The students were asked for their aspirations regarding obtaining their bachelor's diploma in three years. None of the students seemed to care about the three-year term. First they wanted to find out how they could be successful at university, pass the minimum of 30 credits BSA threshold and pass their first year.

From the open coding three other aspects of success emerged. These are described below.

4. Feeling good about one's performance: Mary stated that she needed to make an effort to start preparing for the exams every time, but *"it gives you a kick to look back when you have passed all the exams after having given it your all."* Harald shared this feeling: he felt satisfied when he had worked hard and was rewarded with good grades.
5. Getting up after a fall: Hugo and Marc were confronted with not passing their exams. Hugo failed all of his exams in the first term of the year; Marc failed all but one in the second term. Both failed because they felt that the topics that were covered were very easy and they did not need to put in a lot of effort. Both managed to make up for this failure by working consistently hard during the next term and focusing all their attention and effort on achieving their goals. Hugo stated that he felt 'ecstatic' when he found out that he had passed all his exams in the second term, even though he passed some with the minimal pass mark. Hugo was looking forward to the day he would obtain his propedeutic certificate, because then he will be "*one of the persisters who made it till the end*". Marc was set on passing as many courses he could and felt confident about this.
6. Having a rich student experience. Matt was most explicit about this, but Hannah and Mary mentioned it as well. They wanted more from student life than studying alone. They stated that their side activities and diversions helped them keep up their motivation. Side activities could be very rewarding too; it was a great way for them to meet people outside their courses and to expand their horizons.

5.3.2 | Perceptions of general non-persistence and the BSA

How did students perceive non-persistence? This question was pursued by asking students how they felt about friends leaving university and how they perceived the letter that informed them about their progress in the second education term.

Mike stated clearly in the first interview: "*You don't know if this is for you. You need to commit yourself and if you still fail, that is okay. You know you have given it your best and you can leave with your head held high*." Alex, Matt, Hannah and Howard stated that they learned early on that many students leave the course. They heard this from fellow students, students at their fraternities or had read about it on the university website. Hannah: *"You just hear people talk about it, that 50% leave in the first year so you take that as a fact."* Hugo said that at some point he was looking at pictures of the introduction week and realized he was in pictures with someone he had spent a lot of time with, but who seemed to have disappeared completely. Hugo believed this person had dropped out, but he felt a bit awkward about not having noticed this person's departure any sooner.

In follow up interviews students reported different experiences. The SEPAM students knew that people leave, they just did not know anyone who had and it puzzled them.

They concluded that the non-persisters were the people who never come to class. The students at ME lost some group members. One of them left right after the first round of exams, but he never bothered to inform the team and they needed about two weeks to find out because he did not answer his phone nor reply to their emails. The students were surprised that he left: they had not seen it coming. The students who left were replaced quickly, the project was unhurt and the students got over the incident quickly. The student team at AE lost three members. The AE students talked negatively about Abby. Alex said: "*She quit at the beginning of the second term. She did nothing, she attended project meetings because it was mandatory, just sitting there with her head down. … She was no good at all.*" Alice contended with this statement. The students who try hard were talked about in a matter of fact way. At AP Hannah, Howard and Harald observed students struggle, but it did not seem to affect them. Neither did the letter informing them about their progress.

The students who had been at risk at some point had different experiences. Malcolm admitted in an interview that he was struggling and he found out that ME is not for him. He went to see the student counsellor but he did not get the support he wanted. Prue had not passed many exams in the first round and received a BSA communication in the form of a formal letter in which it was stated that she was at risk and she needed to work harder. She felt cheated, because she had tried hard but it "*just had not happened for her*". Polly agreed, although she herself was not at risk, she felt that people should be able to make their own decisions regarding their studies. She added: *"There is always a story behind delay, they [the administration] should not make such a drama out of it."* For Hugo the letter was a real blow: having failed dramatically he felt bad enough already and he felt the letter informed him he was officially considered a basket case. The letter also served as a wake up call because it formally confronted Hugo with the fact he had passed none of his exams. The BSA created a lot of pressure resulting in lowered self-esteem and a heightened fear of failure. Hugo was affected by the fact that some of his friends left the physics course. In the third interview Hugo said he felt proud that he had recovered from his fall and that he would continue with AP the next year. It seemed to him as if there was a separation between students who did well and those who struggled, but this separation was hard to notice as failure and struggle for success are not discussed openly. Harald responded to Hugo's statement. He disagreed and stated that: "*Everyone in Physics likes the programme and is committed to their own success.*" Harald thrived due to the competitiveness in applied physics. His peer group was very committed and there was stiff competition for high grades. For Harald this served as a source of motivation. As remarked Marc failed in the second term and he did not mention the letter, but he stated that to him the failure felt like a blow and a wake up call.

In conclusion, it is observed that failure is not openly discussed among students. Departure is not talked about as something that is negative per se, but a lack of commitment is. The students who needed support did not seem to get the type of support they would have liked. Student non-persistence is not something that seems to impact the students who stay, or possibly the students who stayed decided not to waste time on those students who were struggling and were looking for a way out of their struggle.

5.3.3 | Perceptions on the education environment

The students were asked which events influenced their experience as students and how. Five codes relevant to educational environment were identified: perceived quality of teachers, assessment and organisation of courses, curriculum and subjects. These codes were explored using open coding and the open codes were revised and combined until there was a consistent set of codes. Different codes could be applied to a single statement, although the researcher made an effort to do this as little as possible, as remarked earlier in this chapter. Next the number of instances that each open code was used was counted and every coded item was assessed whether it was laden with a positive or negative value. In the group interview students could make positive and negative statements on the same topic. Those statements were both counted. Statements with different values could also deal with different issues. The total number of statements and the differences in numbers of positive and negative statements therefore should be interpreted as a difference in magnitude of the overall view students have of their educational experience. An overview of the codes, the number of positive and negative items and summaries of the positive and negative statements is given in Table 5.1.

5.3.3.1 | Course organisation

All the courses had a support system in place. In most faculties there were student mentors and student counsellors. In some of the faculties academic staff fulfilled the role of tutor. Tutors met with students twice in the first year to advise students on academic matters and to discuss their ambitions, and to answer any questions a student might have. Applied physics has such tutorships in place. A tutor did not necessarily have any previous relationship with a student under her or his tutelage. The BSA preliminary advice and a survey filled out by the students served as input for such meetings. Hugo disliked the first meeting. He had not passed any of his exams in the first term and the conversation gave him the feeling that the course administration wanted to get rid of him. Harald did not like his experience either, for different reasons. He felt that the tutor mainly tried to lower his ambitions, while Harald had passed all his exams with high grades. Hannah was quite positive about her experience with the tutor: *"I found it a meaningful meeting. You get the other side of things, the personal side. For example, mind your course load and don't go overboard with the extra-curricular activities. You think: I'm doing pretty good right now and maybe I could do a little more. But the second year will be more demanding, so watch out."*

Howard said he received a plain summary of what he had filled in on the questionnaire and he did not find the meeting useful at all.

The student mentors were generally appreciated, especially when the mentor groups doubled as project groups. At AP the mentor groups were intended for the 'soft side' only. Harald appreciated it as a start of his studies: "*I found it handy: you spend a lot of time together, you go to the lectures together and you see a lot of each other. It was a good way to get adjusted to university as a group.*" Hannah, however, found the programme useless: she felt she could find her own way in the faculty. At AE the mentor groups are also project groups. Alex felt the mentor group added something to his experience at DUT: "*I liked it. I don't think it was because of the mentor group per se, but that you collaborated on the project with these people. Those meetings where we sat together and discussed how you study, those didn't help me a bit*."

The student counsellors were generally looked down upon. They were there to weed out all the students with doubts or insecurities, according to the students. Malcolm mentioned that when he went to see the counsellor, she gave a standard talk. He said: "*I had hoped she would be positive, and she would ask me: what do you enjoy, what are you interested in, that we would explore what I could do because I really didn't like it anymore. But she said that I should just see for myself and reflect on what I would like. I recognised that she had a point, but that was not the reason I went to see her.*" This experience added to Malcolm feeling lost in the course.

Students liked most of the facilities. The buildings and classrooms were considered nice places. The students at ME complained about the failing technology in the classrooms, the lack of computers to do classwork at the faculty and the fact that not all the lectures were recorded and posted online. Many students appreciated the system of recording and uploading lectures. Matt and Marc for instance used the videos when they were preparing for their exams. Matt also watched the videos if he had to skip a lecture for whatever reason. Students found it a shame that online lectures were not available for more subjects. Subjects that went fast, such as Calculus, ought to have more materials online.

5.3.3.2 | Curriculum organisation

Students from all four courses complained about the high course load, long days, poor schedules and lack of information. In AP the weeks when students did lab work were a struggle. The lectures continued, but on top of that students had to spend a lot of time in the lab doing experiments and they had to hand in lab reports on a regular basis. At AE the students experienced a high course load throughout the year. At SEPAM the pressure was very high early in the academic year. In ME and AE the projects took a lot of time. Alex: "*You notice that physically you get drained if you want to attend all the lectures and get work done. The way I see it now it is impossible to graduate in 5 years due to how DUT delivers to* *us*." Time pressure forced students to be efficient and strategic in the decisions they made on what to do and what not. Alex decided not to do two exams, because the project was taking so much time. Marc let go of some resits so he could concentrate on subjects that were important as scaffolds for subjects in the second year. Students complained about the fact that there was always something that needed finishing. You are never just 'done' with anything. The schedule makes it difficult to work out or have a job on the side.

The lecture free weeks were helpful to the students, because they were a break from the attendance regime and they allowed students to focus on one thing at a time. It also created a deceptive sense of space and time. Students tended to think that they could catch up with delays in the lecture-free weeks, but they usually ended up having too little time to cover and revise all the materials.

Students observed that some subjects took much more time than reflected in the number of credits awarded for those subjects. Hannah said about one of the projects that took more time than it should: "*Yes, I did like it, but it was not great. And we only received three credits, while I had put in at least three times that amount of time. At some point you think to yourself: Where does it stop, all this trouble you have to go through? As we were getting to the end I found myself thinking: please, not another meeting….*" Prue says: "*For Differential Equations you only got 4 credits, but you had to do so much more than that. It really was like you were doing two subjects simultaneously.*"

At ME there are so many students that they do not fit in a single lecture theatre. Two teachers teach the same course in different rooms simultaneously. Students can choose to which teacher they go. Many maths courses are taught in smaller groups. Students tend to 'shop' until they find a teacher whose style they like. Although this is not intended by the administration, students were happy that they had some liberties in looking for options that work for them.

Another topic that was brought up several times is the organisation of the project groups. In the first term three AE students left the group but were not replaced, which increased the load for the remaining students. This was considered to be unfair. At ME non-persisters were replaced fairly quickly and they fitted right in. In the second term the project groups were reshuffled. In ME the reshuffling was done based on exam grades from the first term. The best 20 per cent of the students was assigned to a '20% group'. This topic is discussed in more depth in section 5.3.4.1 on perceptions of the social environment, specifically the project groups. Project groups are an important part of the education experience, but it matters how such groups are set up.

5.3.3.3 | Subject organisation

Subject organisation overlaps with the two remaining topics relating to the education environment: student perceptions of teachers and student assessment. Students often identified the course with the teacher and the teacher with the course. If they did not like the teacher, it became hard to judge other aspects of a subject fairly. Topics and quotes analysed in this section on curriculum organisation may pertain to one of the other codes.

A topic that was definitively a part of subject organisation had to do with the learning goals. These were not always made clear to students. This was especially plain when students discussed their exams. When they sat exams they often found out they had not studied the right topics or materials. At AE the physics course stood out. Alice: "*the exam was very general, while the book had a lot more depth. They could have asked more insightful questions. This was like a university preparatory education[13] exam.*" The active learning activities for the physics course were cancelled last minute because it proved to be impossible to schedule these sessions, this was communicated in a blunt and matter-of-fact way. This upset the students, because they felt that the smaller group sessions would have helped them to cover the materials in more depth. Andrew added that he prepared in the wrong way for the physics exam. The teacher had said that they should prepare the whole book, so Andrew summarized and revised the book cover to cover. When he got to the exam, it turned out that it would have been enough to practice old exams and read the book's summary. He failed the exam.

For mechanics the AE students had to submit online tests on a regular basis. The students appreciated this system because it forced them to keep up. At the same time they were annoyed by how this system worked. The system did not allow students to review previous answers and therefore they could not revise and learn from the tests. Another issue students at AE brought up was the fact that the books containing exemplar assignments did not include the answers to these assignments. This made it hard for them to work things out by themselves if they had trouble with the assignments. Mary and Matt stated that when they had to take a course in project management and communication skills, they did not like it because the goals were not made clear, the workshops took too long and they felt that the teacher was just going on and on. In the third interview they were both far more positive about the course, because they felt that the skills they learned in that course were helping them and would also be useful in later years.

In other cases the students were not happy with the content of subjects. The content might be too fragmented, oversimplified, and or sometimes overlapped with topics covered in previous education. Peter says: "*You had to solve a complex problem in a simplistic way with almost no prior knowledge. And I sometimes stopped and wondered: What am I doing here? If*

[13] From here onwards university preparatory education is abbreviated with UPE.

I manipulate a variable, the results will be completely different. So what's the use?" Providing clear content information for challenging topics is motivating for students. This is closely tied in to how students perceive their teachers. A great teacher can make a boring subject a very exciting experience, while a bad teacher can kill anyone's enthusiasm.

5.3.3.4 | Perceived quality of teachers

In total there were 75 remarks made about teachers and this was by far the largest number for any of the categories of codes pertaining to the education environment. An interesting observation is that the students often disagreed with each other on who they felt were good teachers and who were bad. The positively or negatively laden statements could pertain to a single teacher or to different ones. Whether students believed a teacher was good or not depended largely on personal preferences. At AE the following fragment of the interview is illustrative of this point.

"Alice: Now we have this inarticulate German guy for Calculus.
Alex: I think he's great!
Alice: I don't … He's a scatterbrain. He only explains how to do the sums. The previous teacher explained what it was you were doing. But with this guy, I just don't know what to do with him.
Alex: You need to help him find the right formulations, but I think he explains well. He explains the backgrounds of things. It goes quickly and we made real progress in class."

Teachers who have a passion for a subject and who take the students seriously are generally appreciated. Paula said: "*Some presenters are so unpleasant that they are no fun to listen to. … This one teacher just reads what is on the slide and what we can read in the book. But there is this other man from the municipality. He involves you in the lecture and he gives examples that are illustrative, you grock it right away*."

There were some principles of teaching that are appreciated by most students. These had to do with structure, a pace that fitted the difficulty of the topic and the speed with which the students managed to pick up on the topic. Mike said: "*It depends on which teacher you have. Today I secretly shopped and joined another class and he explained things very differently. … This teacher first went through the homework, then explained the theory and after that, he went back to the problems we were solving. Our own teacher just covers the theory and that's it.*" Howard stated it short and sweet: "*He [the teacher] has to be enthusiastic, otherwise I don't care to pay attention and he needs to explain things well. That's it*."

Teachers who were sarcastic and talked down to students were not appreciated and influenced the entire experience students had of a subject. Polly said about a teacher from a maths subject: "*He often says: you study SEPAM, so you will probably not understand this*." Penny said she felt that teachers found the SEPAM student dumb and Paula added that the teachers acted haughty. Pamela stated that she felt that "*a lot of these guys have a seedy attitude towards SEPAM.*"

At AP students discussed their experiences with two teachers:

"Hugo: For me it depends. We have advanced maths now and he [the teacher] shows how to do the sums. Because the class size is small, you have a lot of time to work on the materials. It's not that these teachers are not enthusiastic, but the smaller scale of this class makes it more personal. You are more involved.

Hannah: Enthusiasm helps, it so much better than a teacher who talks monotonously, scribbles on the board and is being sarcastic. That doesn't work for me. … This guy teaching linear algebra doesn't do it for me.

Interviewer: How so?

Hugo: It's his personality. I don't feel he is a bad teacher.

Hannah: No, but he is not enthusiast and he is sarcastic. He acts as if everything is a piece of cake. Like he does not care.

Hugo: You know, you have to hang in there with him, because he enjoys it, but he has this certain way of acting.

Hannah: Well, he doesn't show he enjoys it. … If you ask a question he acts as if that's the stupidest thing you could ask."

At AE Alex and Andrew discussed a computer class that they felt was suboptimal in terms of organisation and support:

"Andrew: What really nagged me was that when understanding CATIA became urgent, there were no opportunities for extra practice.

Alex: CATIA was good, it was new and fun. But the support was terrible. I'm sure that 5 TAs can supervise a group of 60 students, if they would actually do something. Instead, they just sat behind their own computer screens, making fun of us. …..

Andrew: It was a fun class. It was challenging and demanding, but enjoyable. But you had to keep up, everything had to be finished on the spot. The teacher moved through the matter so quickly and that stressed me out. So I would wave to get help, when he came he would show how to do it and before I knew it, he was gone again. I was behind all the time and I was afraid I would fail the class."

At PH Harald and Hugo reflected on a subject from the first term:

"Harald: I found the organisation very bad. When I look at the courses we take now, they are very professional. They [the teachers] greet you when you come in and they introduce themselves to the class before they start.

Hugo: One man said at the beginning: I have been teaching this subject for a couple of years and I believe that this is the best I can achieve. At first I didn't believe him, but when he explained things, I thought: maybe it is impossible to do better than this. I did have a few remarks, but it is different from other teachers who talk under their breath while approximating. … But it's not that they are not nice or anything.

Harald: I completely lost interest in that class because of the way he teaches. But now, I have not missed a single class, because these are just really good teachers. They communicate well and I find it worthwhile to go to the lectures. But with the previous class I felt I could achieve ten times more in an hour of independent study than in those lectures."

Students have different needs and preferences for teachers and how they approach the students. What was considered sarcastic and what not was different between students as well. It is clear that the teacher is the most visible and important part of a subject and course. Teachers and teaching assistents are especially important to students who rely on the teacher for instruction and guidance. Teachers and teaching assistents are important for the general appreciation students have of their educational experience.

5.3.3.5 | Perceived quality of assessment

Assessment of exams and practical subjects, such as projects, proved important to students, because they validated the students' progress according to the standards of the university. It could also be a source of discontent, because the students would like to be assessed on an academic level on the condition that they felt they had been given enough time to prepare for this assessment.

Alex: "I found the level of difficulty in those exams disappointing. I had expected university, but when I got there it turned out to be 4th year UPE. It was like: here is your formula, apply it and that was it.

Researcher: Was it unexpected?

Alice: I don't know. It covered very little material. … You learned so much and then they ask so little.

Andrew: Except for Space. … During the lectures it was overwhelming, it was so much and it went so fast.

Alex: Yes, and we got all these formulas in the slides, but in the end you didn't have to study those.

Andrew: Yes, we had no idea what we had to know and study."

In section 5.3.3.3 a similar situation was described, also regarding Andrew, who prepared for an exam in the wrong way because the teacher had given ambiguous directions on how to prepare for the exam. At SEPAM Prue said about the first round of exams: "*It was just multiple-choice questions and they all came straight from the book. So frustrating.*" Polly however said she could not even remember the exams of the first term, so she "*guessed things were okay*."

Regarding the class on drawing at AE, Alex remarked: "*Drawing is very nice until you are assessed on whether you have talent for it or not. I have talent for numbers and explaining things, but I'm not creative but that is what you are assessed on. I ended up with 6 [out of 10], but don't ask me why. There was no explanation or instruction on how to draw, if you can't pull* *it off at the start, tough luck. … They were discussing the drawings and grades sitting right behind me.*" Alex felt very frustrated about this experience.

The idea of passing exams when students were ill-prepared, is something students did not like, because all these subjects are scaffolded. Marc obtained a 4 out of 10 for an exam he had not prepared for properly. "*I felt like: I should not pass this test. When I looked at the multiple-choice questions, I thought they looked kind of easy. And I could answer a fair number of the open questions and I was thinking: I cannot get a pass grade, because if I do I passed the test without having mastered the subject and I will never study it again. Luckily, I had a 4.*"

Many subjects offered opportunities to sit partial exams: if students passed a number of smaller exams that were sat during the term, they were exempted from the final exam or they would get bonus points on the exam. This way students were encouraged to and rewarded for staying on top of their classwork and this to avoid a peak study load prior to the final exams. In a subject at ME students were required to make homework assignments. To be eligible for sitting the final exam, 30 per cent of the assignments needed to be correct. If students had more than 50 per cent correct, it gave an added a bonus to their final grade. Mary observed: "*I find them positive, these bonus tests and assignments. If you have little time in a week, you will give priority to these tests. That way you keep up with the classes, at least a little.*" Andrew and Mary both said that these tests helped to give an idea of what the final exams would be like which they considered to be a benefit. For Harald the smaller exams at the beginning of the year were formative: "*After those first two weeks I was in the flow and everything seemed to go well. Up until now I have passed all the tests and I have received good grades. But at the beginning it was tough to adapt [to university]. Then I said to myself: OK, I'm going to spend two hours a day on my homework if that is enough to do well. I tried to stick to that plan. That worked out. It's tough but I get good results. And as a result I enjoy it more and more, because I reap from this strategy.*"

5.3.3.6 | Conclusions regarding perceptions of the education environment

A small number of topics scored persistently negative: 'curriculum organisation', 'quality of assessment', 'high course load' and 'fluctuations in course load'. It is possible that this is partly due to the set up of the interviews, where we asked students to rate their overall experiences and discussed the specific events and experiences that stood out in their story lines. Topics that are consistently commented on in a negative or in a positive way will stand out. 'High course load' and 'fluctuations in load' seem to contradict: students stated that they spend long hours taking lectures and on independent study. When they also had lab and project work, they still needed to attend lectures and keep up with their classwork and spend long hours working on practical work. The students in AP, AE and SEPAM at times found it very difficult to combine these activities.

Most educational topics had mixed loads: some aspects were talked about in a negative way, other aspects of the same topic in a positive way. An example was 'Teacher's personal style'. Typical negative statements included: teacher rushes class, does not listen to critique, is sarcastic, teacher is neither enthusing nor passionate, explains in an unstructured way. Typical positive statements are: teacher appeals to and captivates students, is involved, shows passion for the subject, is authentic, takes students seriously, points out relevance of topics, structures and paces very well. Students made contradicting remarks about the same courses and teachers. There is no stick to measure all teachers with: students have different needs and preferences and no single teacher can serve all her or his students equally well, however, all students generally appreciated well-structured and well-paced lectures that added something to the existing materials. For assessment the students appreciated a fair test, be it for theoretical subjects, skill-oriented subjects or project work. The level should be appropriate: the tests should neither be too hard nor too easy.

5.3.4 | Perceptions of the social environment

The students also mentioned a number of more personal attributes that mattered to their success. Codes pertaining to 'students' social environment' were applied 67 times. These codes included the social environment relating to the course and life outside university. All aspects of social environment had mixed influences on the students. For instance, fraternity membership is motivating and supportive, but it also takes a lot of time. It is enticing for students to go to the fraternity bar often and hang out too long. The codes for the perceptions of the social environment, the number of times they were applied and summaries of the statements included in the sublevel codes are listed in Table 5.2.

5.3.4.1 | Project groups and peer groups

Students spent much of their time at their faculty with their project group members and they were considered to be important to their learning. When project groups are not able to overcome the difficulties of a project or problems with group dynamics, it had a major influence on how the students perceived their studies. Howard said: "*I really liked it. The topic was of great interest to me and the group was great. Everyone was supportive. If I had any questions, everyone was willing to help out.*"

In ME the project groups were reshuffled in the second term, based on the grades obtained in the first term. The top 20 per cent students were assigned to '20% groups'. Matt was not qualified to be in one of those groups and he did not mind that at all. Mary and Marc were assigned to a 20% group, but Marc was hesitant at first. He was afraid he might be stuck with "*a bunch of pushy people*". In the third interview he came back to that, because he ended up appreciating his group. He experienced that his group was very motivated and that affected him and his ambitions positively. Mary was also happy with her group. She said she believed she could be dominant, but in her group people could deal with that well and they knew when to stop talking and start acting. Mary and Marc both heard stories from friends who were not so lucky in their non-20% groups. They had to deal with students who were cutting corners or were free riders. They had to deal with this because their marks in the first term had not been perfect. Marc: "*That 20% depended on what you achieved in the first term. I was lucky to pass all my exams. It was not that good, just enough to get assigned to a 20% group. Someone who had tried really hard but missed out on an exam, and who might be more motivated than me, is assigned to a regular group and gets in trouble.*" The ways groups were organised and embedded in the course and subject procedures, could have a major impact. At AE Alex got stuck with a group of low-performers and free riders in the second term. When he brought this up with the teaching assistant, it was made clear that it was considered to be Alex's problem. He did not get any support in solving the issues in the group and he decided to skip exams because he needed to redo a lot of the substandard work of other students to pass the project. He felt that the students should be able to be more involved with how the groups were put together.

Peer groups are important. Hugo says: "*There are some people who stick together, but everyone interacts with everyone. Everybody talks to the others and they go to the same parties. Everyone here has similar interests.*" Harald says: "*I notice there is a lot of competition. I was in a mentor group with guys who wanted to get super good grades and I didn't want to stay behind. We sat together everyday and I thought: I will try to tag along and score well too. And I like it. Normally, I wouldn't do this, but now I'm more motivated, I like it better and I work harder*." Prue had skipped the first year introduction week prior to the start of the academic year. She says: "*I had not attended the first-year weekend. There were a few people I interacted with, but those were guys only. I didn't know any girls. I found that hard. … I didn't really like it. I didn't feel well, because I hardly knew anybody. I didn't have ties, I didn't like the lectures and the people were alright for as far as it went.*" Thing improved for her when she started to make friends in wider circles and at the time of the interview she was enthusiastic about her experience.

Table 5.1 | Codes relating to education environment.

Code	Sublevel codes	Number of statements -	Number of statements +	Descriptions of statements
Course organisation	Communication on progress	5	4	- Progress letter and other forms of communication are negative and unsupportive and are based on unrepresentative sample of tests. + It is like a report card for parents, it is a wake up call.
	Support	5	2	- Student counsellors are unsupportive and going there is bad for your image. Trained academic staff has nothing meaningful to say. Support staff seems to aim to rid university of bad students. Staff member tries to temper student's ambition. + Trained academic staff can be very helpful, the best place to talk about plans and doubts.
	Facilities	3	3	- At the beginning of the year too few computer that are too slow, no chill out zones. + Opening hours of central library, good atmosphere on campus and in the buildings.
Curriculum organisation	General	12	-	- Scheduling at unfavourable times, last minute cancellation of educational activities, lack of flexibility, lack of information.
	High course load and pressure.	17	4	- Long days, long hours for longer periods of time, many different demands and little time for relaxation. + This pressure makes students more time efficient. It is not that bad.
	Fluctuations in course load	8	2	- Practicals, projects and resit exams add to an already full workweek. + Lecture free weeks give something of a breathing space and time to prepare for exams.
	Alignment of educational activities	1	5	- Sometimes content needed in projects has not yet been covered. + Sometimes content of maths and physics fits in well. Organization of project groups is organized in such a way that non-persisters do not disturb the groups' progress. Mentor groups that double as project groups build trust.
	Having choice in education matters	7	2	- No say in team composition, when students leave project groups, they are not always replaced which increases the burden of remaining students. + Parallel groups in maths, students decide where they go.
Subject organisation and level	Clarity learning goals and assignments	8	5	- Unclear what lectures are about and what students are supposed to learn, lectures poorly structured. + Project assignments make lectures more meaningful, course in project skills make a lot of sense in retrospect.
	Availability and accessibility of learning materials	6	3	- Book is difficult to read, book is in English, book is fragmented, slides can not be read or are unavailable, maths classes are not available online, no answer keys to exercises in books. + Good book with plenty of meaningful exercises, lectures taped and available online, teacher helps translating concepts to English.
	Content	12	12	- Content of course is trivial, too easy, oversimplified, boring, is covered in pre university education. + Clear content, helpful feedback, assignments add meaning to lectures, the content is inspiring and motivating.

Code	Sublevel codes	Number of statements		Descriptions of statements
		-	+	
Quality of teachers	Personal style	17	19	- Teacher talks down to class, rushes class, is unavailable, does not listen to critique, is sarcastic.
				+ Teacher appeals to students, captivates them, is involved, shows passions for the subject, is authentic, is available, takes students seriously, plenty of personalized attention.
	Didactical expertise	16	23	- Teachers are neither enthusing nor passionate, explain poorly and unstructured, lectures are poorly paced.
				+ Teachers rouse students' enthusiasm, point out relevance of the topics, structure very well and take time.
Quality of assessment	Quality of tests	13	3	- Exams are too easy/too difficult, assessment does not fit learning goals, unfair and non-transparent procedures.
				+ Tests are doable and okay.
	Clarity of assessment	8	4	- Learning goals only become clear at the exam itself, "practice exam" is not representative, partial exams make exam fragmented.
				+ The partial exams are helpful.

Table 5.2 | Codes relating to student social environment.

Code	Sublevel codes	Number of statements -	Number of statements +	Descriptions of statements
Student social environment	Attitude project group	8	8	- A project group that does not function well, has an adverse effect on students. It sometimes makes students depreciate their studies as a whole. Unmotivated peer/friends have a detrimental effect on your own attitude. + A good project group and motivated peers are very supportive and engaging. What makes a group 'good' varies per student, e.g. mentoring programmes are genuinely appreciated by some and a drag for others.
	Attitude peer group	4	8	- Some groups tend to be close-knit and if you do not fit in, things get lonely and it leads to insecurity and self-doubt. + Students share an interest and that creates a good atmosphere. Friends who go to lectures are motivating and supportive for studying together and you have more fun breaks.
	Fraternity and sports associations	8	5	- Fraternities and sports take a lot of time because of various requirements. Sometimes students are not at ease at their association, but that is something you learn as time goes by. + Associations and fraternities are the social glue of student life. The time pressure forces you to be efficient, it creates diversion and fun.
	Boards and committees	3	4	- Some students take on many responsibilities that make the course more fun, but other do not do anything. Boards and committees take a lot of time. + Participation in these extra-curricular activities creates variety, which is motivating.
	Housing situation	8	5	- Finding housing is not always easy. The students who live with their parents feel they have fewer opportunities to study: they are expected to do chores and need to commute. Living at home forces you to give up opportunities for an active student life. + A fun house is homey, but it can also create temptations to spend too much time with flatmates and too little time studying. Family members do not always know what studying is about, while flatmates know very well and can be a great support.
	Family support	3	3	- Some parents do not always know what studying is like and when students are at home they want a lot of attention and leave little room to studying. + Some parents are supportive and support students in setting goals. Spouses can be helpful and tend to be good listeners.

Table 5.3 | Codes relating to discipline and study behaviour.

Code	Sublevel codes	Number of statements		Descriptions of statements
		-	+	
Motivation	First perception and motivations	6	6	- If you do not feel happy, you cannot achieve anything. Some students found the generic introduction courses boring and unmotivating. The transfer from UPE to university is not easy, you have to learn what the expectations are of you. + You should only pursue this kind of education if you are certain you want it. You sometimes need to reconnect with and/or rekindle that passion, otherwise you cannot keep it up. Difficult subjects are challenging and worth wile to pursue.
Strategies and effort	Learning preferences and strategies	19	23	- It is not always easy for students to assess how well they have mastered subjects or how much time they need to invest to master a subject. It is hard to get yourself motivated for a course you do not like, such as advanced maths. Finding time for leisure is not easy. + If you are motivated, you can keep up they study regime and it is easy to spend a lot of time on the things you enjoy. Sometimes you need to let go of one subject so you can concentrate on another one. Some students find that cramming works best for them, other students plan meticulously and other students rely on both strategies.
	Going to lectures	9	7	- If you go to all the lectures, you end up with a burn out. Some lectures do not add anything and/or are fragmented. + Some students do not keep up with the homework, but go to all the lectures because in spite of everything you do pick up many things by just being there. Other students go to the lectures that help them, and work by themselves on subjects where lectures do not add anything to the book.
	Time and effort	8	7	- Some students would like to do more, but they simply cannot manage that: the courses are very demanding and it is hard to juggle time and responsibilities. + Keeping up takes a lot of time and it is not easy, but it yields good results. Good schedules help: those are schedules that leave enough time for leisure and help with planning by means of partial exams and activities where you work on homework exercises.

5.3.4.2 | Social support and activities

Student associations, sports or music associations and study associations are prevalent in Delft. There is a distinct difference between student associations or fraternities and study associations. Fraternities are private societies that are open to students of all courses and they tend to focus on social events or other activities that reflect or support their missions, denominations and/or traditions. Some sports associations double as a student association, because they offer more than sports alone. The study associations are strongly linked and sponsored by the faculties. These associations also offer books for affordable prices to their students, organise course related events and so on. Students run all of these associations. These associations have designated boards to organise specific activities relevant for their specific denomination or traditions. Serving on these boards is seen as something worthwhile for students for it is generally regarded as an extra-curricular activity that is useful for finding a job after graduation.

Some students do not become members of any of the associations; other students become members of multiple associations, boards and so on. The students at SEPAM and ME stated that the events organised by the study association were helpful for their studies. It helped to create context for the content of the course. Marc had a similar experience. He enjoyed going to lectures organised by the study association of ME because there often are companies giving presentations on innovative projects they work on and they showed a genuine interest in the students as possible future colleagues. Mary was a member of a student association and she found it enriching for her studies. She talked about a meeting organised by the association to discuss study strategies and habits for success. Matt was a member of a traditional student association with mandatory activities and he enjoyed it a lot. Matt said about the introduction term: "*We had this two week ragging thing going on and I'm glad it's over. It gets irritating that you cannot decide how to spend your time. … Now we just have drinks twice a week and it's really great and sociable. I know many people, which is fun and helpful in finding housing*." As stated in section 5.3.1 on success intentions, Matt said that his intentions for his studies were to have an enriching experience, which meant he wanted to pursue ME, but he also wanted to take part in extra-curricular activities that bring satisfaction and fulfilment. Abby said in the first interview that she found it very difficult to devote enough time to her studies because of her activities at her fraternity.

Hannah was a member of a sports association. In the third term she organised a tournament: "*Six weeks prior to the event it was the only thing I spent time on. It was great and definitively worth it, but I skipped a lot of classes. It's tough to catch up. I will manage somehow, but I was happy with the variety, with not spending time on my studies.*" Other students signed up for student associations but they did not feel like they really belong. They cancelled their memberships and stated that they did not feel as if they are missing out on anything without such a membership. Peter, Paula, Matt and Hannah had a lot of activities going on the side. They all said that it was a matter of planning to be able to combine such activities with studying. They had little time and they made an effort to spend the available time wisely and efficiently.

Marc and Hugo both moved out of the parental house during the year, not before they started their studies. They experienced that they did not find it easy to live at home and, after they moved out, to go home on weekends. Hugo's parents showed little understanding for his need to work on his assignments and he had to do chores when he got home from the faculty. Matt told that when he would be home on weekends, it was hard to find time to do some homework. His parents expected him to tag along with the family's routines. In the last interview Hugo said: "*I don't involve my parents in my studies. I don't feel the need to bring it up. I discuss things with my girlfriend. She just started studying herself. She's all about discipline and planning. She lifts me up in that sense*." Hannah and Howard stated that they received a lot of support from their parents, although they felt their parents could not relate to their experiences as students. Mary said that it was tempting to spend too much time with the flatmates and going out together, but there were advantages as well: "*You kick each other in the pants if you see that someone is skiving. And when you see that someone is really engaged and working hard, you encourage that person to continue. Parents don't really know much time you need to spend, how much pressure there is or how difficult it is. They rather seem to be worried that you do not spend enough time on your studies, while you know your fellow students, you know how smart they are and how much time they need to work on stuff.*"

5.3.4.3 | Conclusions regarding the perceptions of the social environment

Codes pertaining to the social environment were applied 67 times, but the sub-codes refer to different social circles and again many of the codes comprise positive and negative statements. Based on this it should be concluded that the social environment plays an important role in the lives of students, but that the experiences students have in this setting are very different. Some of the settings can be partly influenced by the university. The project groups and the procedures around them, are within the sphere of influence of the courses and the university can confer with the associations regarding creating favourable conditions for the students to study and relax, however, membership is voluntary and not all students are members of associations. Therefore, in the end, universities can have a small indirect influence via the social environment on student success at best.

5.3.5 | Motivations and study strategies

Motivations and intentions were identified as important predictors of success in the previous chapters. Motivation and strategies are mentioned often when students are asked to reflect on their experiences in their first year, they also sometimes overlap with the topics discussed above and with the other.

5.3.5.1 | Motivations

All of the storylines showed that the students were very excited and motivated right at the start of the year. For some students the motivation dropped very fast. At AE the students reported that one group member left after only after three days, because he found the course extremely hard and overwhelming. Most students start out with a UPE mindset: they had always got away with making little effort and were not used to having to study. Howard said that at UPE, his maths teacher often told him he did not have to do some of the assignments because he had got it anyway. Hugo got into trouble as a result: he was taking things easy in the first term and thought he was doing well until he learned that he had failed all the exams of the first term. At AE all UPE topics are covered in the first two weeks of maths, as a refresher. Although some students felt overwhelmed in those weeks because the classes were fast paced, they experienced the fact that they already know most of the subject matter. They were in for a big surprise when new topics were introduced at a similar high pace after the UPE topics had been reviewed. Some found it hard to pick up the pace.

Prue and Polly did not enjoy the introductory courses at SEPAM, they found it too generic and boring. They regained interest when they could take more specialised subjects later in the year. At applied physics the second term was generally considered boring, because some of the subjects were taught in an unappealing way. Students were relieved in the third term when the subjects taught touched on more interesting matters, that the subjects were taught by more enthusiastic and more gifted teachers and the schedule permitted the students a little more freedom. The level of the courses was generally perceived as positive: sometimes it was really hard, but students generally appreciated challenging subjects. That is what they came to Delft for: to learn. The students got a kick out of mastering new topics that captivated them. Students found new courses and new practical work motivating and refreshing. Students at AP do their third term lab work with research groups. They interacted with university staff and found that very rewarding. The atmosphere was more laid back and they were more a part of the physics faculty.

Most of the students had ways to rekindle their motivation when they were about to lose it. One of Matt's strategies was to read technical magazines or watch the Discovery Channel, because he found the documentaries on engineering inspiring, these brought out what a captivating field ME is. Some students hung out at the study and student associations to connect with fellow students, they attended presentations on their fields, took a break or a holiday, and so on.

5.3.5.2 | Strategies and effort

Codes regarding strategies and metacognition were applied 82 times. The sublevel code of Learning Strategies and Preferences was applied most often. A topic that stood out was that at the beginning of the year many students reported that they had difficulty assessing how well they had mastered the materials. This seemed to get better as the year progressed. At first students often did not know what to expect, sometimes as a result of poor communication by the teacher, as discussed in section 5.3.3.4. Hannah said: "*After four weeks things seemed to fall in place and you got to know more people. It made it more fun to come to class and the atmosphere improved, because of that the overload of subject matter wasn't so bad anymore*." Later she added: "*The second round of exams, I felt more confident. The first round of exams I was doubtful whether it would work out, but the second time I knew I had already pulled it off once, so I should be alright*." The outcomes of the first rounds of exams seemed to surprise some students. For instance Hugo believed he had passed most of his exams the first time, while he failed all of them. For Alice it was the other way around: she believed she must have failed everything, while she passed all her exams with acceptable grades.

The students who continued in their first year all had some sort of study regime and they tried to stick to it. In spite of this regime Hugo and Mary reported that they felt they were not doing enough. At the same time they made it clear they were unable to get more done. They needed off time occasionally and simply could not motivate themselves to study all the time. Hugo said he believed he did not do well with keeping up with homework assignments, but he went to all the lectures and kept up that way. Harald had a system of spending at least two hours a day on independent study, while Matt had a more laid back regime of loosely keeping up with the lectures and cramming what still needed to be crammed in the lecture-free terms prior to the exams. If Matt could not attend a lecture, he watched the videos posted online. Mary, Matt and Hugo stated that every time they started preparing for the exams in the lecture-free terms, they were startled by how much subject matter they needed to cover in spite of their study strategies and the discipline they maintained. The other students reported other, similar strategies. Going to lectures was one of these strategies. It took a lot of time, but even if the teacher was not great, students still picked up a lot from it. At AE Andrew and Alex said that they would get a burnout if they went to all the lectures, so they came up with a strategy: at the start or each new subject they attended the first lecture and decided whether it would be worth going there or if they would rather study the subject by themselves. It was not always easy to keep up with the regimes, but it yielded results, which made it worth it. It helped students if the schedules were such that they had time to schedule around events they enjoyed. Students liked being able to have some time to let their hair down or to work out. Knowing they had other things to do at night helped the students to be efficient with studying during the day and to not procrastinate. The partial exams also helped students to avoid procrastination.

For most students it proved to be helpful to move to Delft if they had long commutes. In the last round of interviews it was found that all of the students with long commutes had moved to Delft and they appreciated their new lifestyles and the extra time they could devote to studying.

Students cannot study all the time, at some point they need a break: they go on holidays, organize events, work out, do something to break their routines. Planning was found to be important: even Matt made schedules for studying, he also deliberately planned time for his other activities. The amount of time students put in studying depended on how much time they had on their hands and on how important they felt it was to keep up with class work. If keeping up had served a student well, she or he will probably try to maintain this strategy. If keeping up has proven not to be necessary, a student will not change her or his way until it goes wrong. All the students talked about working hard and they attributed their success to their commitment to putting in effort.

5.4 | Perceptions of non-persisters

When students were recruited to participate in this study, they were informed that the researcher would like to interview everyone who would not persist in the course. Four students left during the first year, two from AE namely Abby and Asher and two from ME namely Malcolm and Melvin. Abby and Asher participated only in the first interview and had left before the second interview took place at AE. Abby could not be traced for an interview, but Asher was willing to participate. Melvin only participated in the first interview and also could not be traced for an exit interview. Malcolm participated in the first and second interview and participated in an exit interview at the end of the year. The exit interviews with Asher and Malcolm were done by telephone, using a script of four questions. The script is presented in Appendix 2. The researcher made notes during the conversations and wrote detailed reports directly after the interviews.

Asher admitted his first field of choice was medicine, but he was rejected for that course. He chose AE because he found AE appealing. Soon into the year he found out that the emphasis lay on maths and physics, which he found boring. He started to inquire after the kinds of jobs aerospace engineers held after graduation and found that maths and physics continue to be their focus. Asher sees himself as more of a people person and AE proved to be a poor match. He did have a lot of friends at AE, but he remarks that these people tended to be withdrawn and focused only on their studies. Asher found these people a bit on the nerdy side. Asher found that the level and pace of the course were tough. He felt he had too little time to work on the assignments and to spend on work, leisure and family. Asher regarded himself as an average student. In January it became clear that P-in-1 was not attainable for him and he went to see the student counsellor. He learned that there was no point in trying to obtain P-in-1 anymore, that putting in more effort would not help him if he was accepted at medical school the next year and he was advised to withdraw from university. Malcolm also had trouble with the high level and proportion of maths and physics at ME. He found the lectures too large and impersonal and he did not feel connected to any of the teachers. There was a complete lack of interaction in and outside the lectures. There is little structure and no 'big stick' to get moving and to maintain the necessary discipline to keep up with classwork. Malcolm reported that the practical side of ME was captivating and the people were fun. He really enjoyed the technology. Malcolm passed all the courses of the first term, but had forgotten to enrol for the exams in the second term and was therefore excluded from participation, however, Malcolm said he felt he had not really done anything throughout the year. He had real trouble with the amount of independent study that was expected. He found it hard to open his books and to persevere with working on his assignments. As the year progressed, it got worse. For Malcolm it was a hindrance that all the textbooks were in English. He was good at English, but it was yet another barrier to perseverance in studying the subject matter. Malcolm felt overwhelmed with all the items he had to keep up with. There were many parallel systems that you needed to check on a regular basis. You needed to enrol for exams, you needed to check if you were required to get study materials, you needed to check your schedule because things change all the time. Malcolm would have preferred a study environment where he knew what to expect and where he knew what is expected of him.

When the stories of Malcolm and Asher are compared with the reasons for leaving STEM disciplines reported by Seymour and Hewitt (1997) and Warps et al. (2010) there is a lot of overlap. Both students had made a poor choice of field: they did not know about the vast amounts of maths and physics involved in engineering. Both were overwhelmed by the difficulty and pace of their courses. Asher learned that careers in engineering did not appeal to him and Malcolm was turned off by how the education was offered in his course. Malcolm attributed his failure partly to his own attitude and partly to factors in the educational environment. Asher attributed his failure to his 'average' ability, the lack of time he had to study and his loss of interest in the field. The reasons for leaving of these two students are not surprising and fit with the knowledge base on this topic. It also shows that although these reasons are well known (Baillie & Fitzgerald, 2000; Heeringa, 1998; Seymour & Hewitt, 1997; Warps et al., 2010) they are still current reasons and still of importance to anyone who is interested in studying student success and drawing up policies designed to mitigate these factors.

5.5 | Contributions to a preliminary model for DUT first year student success

5.5.1 | Outcomes of this study

In this study the leading research question was: Which variables are related to success for first year engineering students at DUT and how are these variables related?

Six different conceptions of success surfaced in the interviews. Some students set their sights on obtaining their P-in-1 in one year, but this was as far as the students planned ahead. The propedeutical diploma allows students to take on positions as teaching assistants or become board members in, mostly university-sponsored, student associations and some students aspire to obtain their P-in-1 because it would make them part of an elite. Apart from this, the P-in-1 serves as a higher goal for some students, while others view it as a two-stage rocket: first pass the BSA threshold, then try for the P-in-1. Only a few students explicitly mentioned that grades mattered to them, but most students did not mention good grades as a measure of success. Some students said they did not like the idea of scraping by their exams, because it would mean they understood too little of the course to be able to scaffold new knowledge on top of it. When things get rough, the grades do not matter as much anymore. After having failed a number of exams, Hugo needed to pass all his courses to pass the BSA threshold: grades were unimportant as long as he fulfilled his goal. Other students did not care about P-in-1, because they felt it was not feasible considering their high course load and the fact that only small proportions of the student population had made it in the past.

Other notions for success included having a rich student experience with achievements in academics coupled with achievements in the social arena, and the experience of feeling good about one's achievements in academics and the ability to recover from failure and passing subjects in spite of the odds. One could argue that this pertains to the notion of feeling good about one's achievements, but the students who failed at some point needed to make up and prove themselves. The focus on P-in-1 for reasons of taking positions in boards or to experience that one is part of an academic elite, can be viewed as a sign from the competition and "weeding out" mind-set that is present in engineering culture. As is common with cultures, it is hard for participants in the culture to express exactly what it is. At AP competition was brought up as a topic, and in ME competition is corroborated by for instance the inception of the 20% groups. Based on these observations we conclude that the "weeding out" culture and competition are also a part of the DUT culture. Once students fail, they need to work hard to catch up. That is part of the culture and became more pronounced with the implementation of the BSA, but it is very tough, as students need to catch up with their resits and keep up with new subjects. The students who expressed the desire to be part of the elite, also mentioned they worked very hard for it. From this, we conclude that goal setting, planning and sticking to it, is an important factor to success. A second major factor is to put in the necessary work and effort to achieve it. This also goes for the students who do not aspire to obtain their P-in-1: they set different goals, also outside academia, but they will still have to put in enough effort to pass their exams and attain their other personal goals.

Factors pertaining to issues in the teaching and learning environment also emerged from the interviews. The students were clear on the importance of organisation of course, curriculum and subjects and the importance of the quality of teachers. There was some interaction between these two elements as good teachers can help mitigate issues with organisation and vice versa. At the course level poor organisation pertained to communication about the BSA, support from counsellors and facilities. These were fairly well defined units and it was generally easy to agree or disagree with whether there were enough computers for students to work on or if the ratio of counsellors to the population of students was sufficient. When discussing curriculum organisation students brought up course load, misalignment of educational activities with project work and lack of communication. These outcomes were harder to interpret, as there is no clear way to operationalize these concepts and understand them in this context. What could be effective communication in the eyes of the administration could be poor communication in the eyes of some of the students, whether it pertains to communication on the BSA or matters of course and subject organisation. Between 2004 and 2009 DUT commissioned an independent research company to study the logistic quality of the education environment in all the faculties (Rezai, De Boom, Weltevrede & Hermus, 2009). This research was based on the perceptions of DUT students. The researchers concluded that the scores on e.g. information and schedules at the faculties of AP, ME and AE did not deviate from the DUT average. One could wonder if the students participating in this study were more critical as a result of the selection procedure, or if the quality of information and schedules was particularly substandard. In any case, as long as students complain about these issues obstructing them from being successful, it should still be considered to be a problem by administrators as it continues to be a point for improvement. The quality of communication pertaining to the BSA and curricular matters needs further clarification. Communication on the BSA has not been studied before and it was not clear how the perception of poor communication was related to factors pertaining to success.

Pedagogical and didactical qualities of teachers were mentioned many times by students. When teachers manage to appeal to students and create a nurturing learning environment, this helped the students to overcome issues of discipline, effort and poor organisation. The students shared experiences of didactical expertise: effective teachers divided the subject matter in recognizable, internally consistent units, structured well and aligned the pace with the level and needs of the students. On a personal level an effective teacher takes their students seriously and is enthusiastic about their subject, however, a teacher who is greatly appreciated by one student may induce resistance in another. Not all students agreed that the pace was good, or that a joke was funny or sarcastic. If students do not appreciate the teacher, they might still go to the lectures to stay engaged with the subject or they will study the material from the book.

Topics pertaining to student attributes, such as ability, were not brought up by the students, except by the two non-persisters. Asher attributed part of his decision to leave engineering to his lack of ability in physics. Malcolm brought up a loss of interest in his course and stated that he had never had a lot of interest in maths and he found it very hard. Hugo failed his exams in the first term and reported a loss in confidence in his ability. He managed to make up the delays and he attributed this to working very hard. Other students reported feelings of insecurity about whether they spent enough time on their studies or if they had truly mastered the subject matter, but none of the students who had not had a clear fail experience brought up the topic of ability. Failure was not discussed openly among the students. The students who left seemed to disappear suddenly. Students who failed at some point or decided to leave reported different experiences with the education and social environment than students who had not failed at any point. These groups of students have different perceptions of the group dynamics, and of the available support and teaching. Asher and Malcolm, the only non-persisters who participated in this study, reported a number of reasons for non-persisting that have been found by Seymour and Hewitt (1997) and Warps et al. (2010). They reported a poor choice of field, both did not realize in time how much maths and physics was involved and they were overwhelmed by the difficulty and pace of the curriculum. One of them found that a career in engineering was not appealing, while the other was put off by the way education was organised and offered. As in the research by Seymour and Hewitt and Warps et al. it could be that in this case many of the persisters shared some of these ideas, but had managed to overcome these issues and rekindle enough motivation to continue.

Students attributed most of their success to 'working hard'. "Strategies and effort" is the overarching code applied most often in this study and this fits in well with the observation made at the beginning of this subsection on students relating their success to goal setting, planning and effort. The 'strategies and effort' code pertains to a student's learning preferences, how they study and how they apply to how much time and effort a student spends on their studies. These outcomes fit in well with existing literature on this topic, for instance with work by Carroll (1963) who postulated that time and appropriate study behaviour are essential to achieve any learning outcomes. Van der Drift and Vos (1987) and Bruinsma and Jansen (2007) also found negative effects from procrastination. Setting goals, sticking to planning and continuing to work hard can be considered as effective behaviours. It also fits in well with notions from attribution theory in which it is postulated that students who attribute their success to factors under their own control tend to do better than students who attribute success to factors such as luck or ability (Pintrich & Schunk, 1996). The category 'strategies and effort' currently does not shed light on possible patterns within the sublevel codes, nor does it contain points of reference as to how these categories are related and how they are related to success as a whole. This will need to be explored in more depth.

Course, curriculum and subject organisation was another major factor emerging from this study. In chapter three we concluded that the teaching and learning environment did not have any direct effects on student success, but there is a large body of knowledge that reports on numerous aspects of course organisation that have small indirect effects on success. Taken all together the total effects should not be underestimated. The same goes for another major factor that emerged from this study: the pedagogical and didactic qualities of the teachers. Jansen and Bruinsma (2005) for instance, found that perception of the instructor was negatively correlated with keeping up with the subject matter and positively correlated with involvement in class. Vogt (2008) found that perceived distance to faculty lowered student self-efficacy, academic confidence and GPA engineering. There is also support from the literature for the observations made by the students, however, it requires more study to find out what kinds of behaviours and qualities are related to student success in DUT. Students also brought up issues with assessment. They found that the quality of exams was lacking and that there is room for improvement in the feedback on projects. This topic did not emerge from the literature review, but that does not mean that the students' views are not valid. In an environment where there is a strong focus on achievement and competition, it is not surprising that the exams and tests are under the students' scrutiny.

The final factor that emerged from this study is the students' social environment. There is a lot of support from the literature base for this topic, a notable study being the one done in the University of Groningen by Eggens, Van der Werf and Bosker (2007) who found that strength of personal networks positively affected student success. In engineering education there is support for the notion that the quality of project groups are of great importance to the students' social environment affect the learning processes, e.g. study behaviour and effort, and outcomes.

5.5.2 | Discussion and limitations of the research

An attribute of qualitative research is the relatively small number of participants that can be included in such a study. As a result only a small number of non-persisting students could be tracked down. In total 24 students participated, but 7 of them participated in only one interview. In the case of SEPAM and AP we did not have any non-persisters in the group, probably as a result of the way these groups were recruited. The only way the researcher could check whether students were still persisting, was to ask fellow students and to learn from automated replies to emails confirming that an account was closed. The researcher was informed of three names of students who had left, but there were several other students who did not respond to emails for reasons unknown. It is possible these students no longer wanted to participate in the research, but the reasons for non response could range from lack of time, mailbox overload or avoidance of the topic of (non-)success. One of the non-persisters did not respond to any communication. Two were willing to discuss their experiences, but this group was so small that the non-persister interviews only generated anecdotal data. As a result of how students were recruited in AP and SEPAM it was not possible to talk to a single non-persister in those courses. It is possible that only a certain sub-population of students are willing to participate in research like this. It could be that these students are more able and willing to explore and express their opinions on personal experiences in a group than other students. Further research is needed to collect more data, particularly from non-persisters, to be able to understand the shared concerns of students who stay and who do not, and to understand success and failure among DUT students as two related but separate stories.

The data was not complete because it was not possible to interview the students from AP and SEPAM three times during the year. We did not combine the interview data with data from the student database. We have some information on the students' age, grades for maths and physics and their previous education, but no information on progress during the year. We relied solely on the data the students gave us. In transcribing the interviews it was not always possible to retrace who said what. The data that was available allowed for exploratory research at an individual level for some students and at a group level for others. This is a result of the methodology used, but it does limit the kind of inferences that can be made based on this data.

The codes were developed by two raters who coded a number of documents independently to check if they had similar conceptions of what the codes entailed and which codes applied to which fragments, however, the final coding was not reviewed by a second rater. In spite of the diverging and converging process used to develop codes and coding documents, this is a potential source of bias in the analysis.

The rationale to carry out this study was to explore students' perceptions of success and the variables that they perceive influence their success. Special attention was focused on the newly introduced policy measure to increase success: the Binding Recommendation on Continuation of Studies (BSA), i.e. the rule that 30 credits must be obtained before a student could register in the second year. Based on this study it can be concluded that students view success in broader terms than it is common viewed in policy and research. The BSA was taken by many students to be an additional source of pressure, especially early on in the academic year when students were not quite sure what to expect. The way the BSA communications were phrased and implemented was generally not viewed as supportive.

A side effect of the recruitment and students' willingness to participate in this research on student success is that while it is possible that the information gathered in this study is useful for understanding success at DUT, it is not for understanding failure. In chapter three it was argued that success and failure are not mirror images and that models to explain persistence could be different from models explaining non-persistence. For the research project it was important to verify the outcomes of this very small sample of students with the experiences of a larger group of students at DUT, with a special focus on finding non-persisters to check if the above findings also apply to them.

Chapter 6

Study 2: A further qualitative inquiry of first year student success with student cohort 2010

6.1 | Introduction

In the previous chapter we explored how students from cohort 2009 looked at success and we looked at factors that contributed to their success. Students have a wider understanding of success than obtaining credits alone, although this is an essential part of being a student. Students reported that teachers had a profound influence on their success, however, students had different perceptions or their experiences with teachers; the same experience or teachers could be appreciated by some students, but disliked by others. It is unclear at this time what kinds of teacher behaviours are generally appreciated and what kind of behaviour is not. Students reported the detrimental effects of heavy course load, misalignments between topics covered in lectures and in projects and poor communication. Students also reported the importance of working hard: codes pertaining to learning preferences, strategies and time-on-task were applied often, however, it proved to be difficult to study patterns within these categories to create more understanding of how students viewed these topics in relation to the other topics and to success. The students shared their opinions on the BSA. They experienced it as an additional source of pressure, mainly at the beginning of the first year when they do not yet know if they would be able to be successful and when they had failed and were not sure if they could make up for the failure. Communications around the BSA were perceived negatively because of timing and phrasing.

In the previous study we attempted to involve non-persisters, but this proved to be very hard. The non-persisters we managed to talk to reported experiences and reasons for non-persistence that are in line with the literature, however, as there were only 2 non-persisters who participated in interviews, it was hard to get their insights past the level of anecdotal evidence. The data was incomplete in other ways, because it was not possible to do interviews with students from applied physics (AP) and system engineering, policy analysis and management (SEPAM) early in the year.

The set up of the study discussed in this chapter, was similar to that of Study 1, but the study was set up with different goals: the small exploratory study with students from cohort 2009 was intended to get a rich understanding of what variables matter to success in the perceptions of students. In Study 2 we replicated Study 1 with a larger sample of students representing more courses, because we were interested in finding out if we saw similar overall patterns in the data concerning the variables and factors identified by the students as being important to their success. There were gaps and limitations in Study 1 that needed mitigation: the topic of study behaviours still remained murky, there were many questions concerning how students saw the relations between the variables they had come up with and we still knew very little about the students who do not persist in their courses. The research question guiding this study was: Which variables are related to success for first year engineering students at DUT and how are these variables interrelated?

6.2 | Methodology of the group interviews

6.2.1 | Group interviews and stimulus objects

The methodology used for Study 2 had many similarities with that used for Study 1. Student mentor groups were recruited from different faculties and interviewed three times during their first year. The first two meetings took place early in the year (September 2010) and halfway through the year (January or February 2011). The third meeting took place around the time of the final round of first year exams late June 2011. The focus of the first two group interviews were the experiences and perceptions of first year students in engineering in DUT to learn how the students viewed success in their first year and beyond, how they related to their environment and how in their perceptions attributes of that environment were linked. Again the stimulus objects were used to elicit student narratives and to stimulate dialogue between the participants and the researcher. The third interview, however, was organised in a workshop format with students from different courses collaborating to model their own student success. This format will be explained in section 6.2.2.

The first interview was semi-structured and touched on three topics: choice of field, social environment and first impressions of the subjects and the course as a whole. In the second interview the students were asked to look back at their experiences of the university so far. In both interviews stimulus objects were used. Stimulus objects are used to provide a participant with a visual that can elicit a dialogue between respondents and a session moderator and they can help to capture this dialogue (Padilla, 1999). The stimulus objects used in the first interview consisted of 5 large prints of schemas that were used to map the students' answers. The first page contained a schema mapping out the axes of the Beta Mentality model (Betamentality.nl, 2009) which was used to discuss the students' motivations for taking their courses. The second page contained a list of all kinds of networks and platforms students could participate in that shaped their social environment. Students could indicate what networks and platforms they were part of and how important this participation was to them. The next pages contained basic questions on the students' experiences and opinions on subjects they were taking at the time and the last page contained similar questions on the students' course as a whole. In the second interview storylines were used. These were supported with a set of predefined questions that the researcher could use to aid to conversation. The stimulus objects, interview guides and consent form used for Studies 1 and 2 are included in Appendix 2.

6.2.2 | Workshops for modelling student success

For the third meeting a workshop format was chosen to collect data. Students in DUT are used to working on modelling assignments in small groups. In these workshops the students were invited to work on a similar assignment, although this time they were asked to model 'student success' instead of covering a course assignment. We assumed that this would be a natural environment for students to cooperate in and to feel free to express their ideas. The workshops took place at the end of the academic year of 2010/2011, prior the exams of the second semester. They were scheduled to take about 2 hours each. In total 4 workshops were organised. Each workshop started with a short introduction of the aim of the workshop and a short round introducing the participants. Next, the students were informed how the data would be used and they were asked if there were any objections against recording the discussions. This was followed by the practical instructions for the workshop using a snowball method. Students were first individually issued forms on which they were to list 5 variables, events, situations, aspects, behaviours, activities, etc. that were helpful to and 5 of such factors that were detrimental to, their success. When they finished this assignment, they were to pair up with someone else and compare their lists. Together they would draw up new lists of helpful and detrimental factors. The outcomes would briefly be discussed in the wider group while all the factors were written on sticky notes.

The next step was to use the sticky notes to model success. The instructions for the process were simple: the output variable 'success' was given. Students had to use all the sticky notes but could group some of them if they believed there was a lot of overlap between factors. Between factors, students could draw arrows to represent causal relationships, which remained undefined. Only one or two arrows could be drawn from each factor, but the number of arrows going to a variable was not fixed. A typical model would look like a flow chart. Students were given large sheets of paper to work on and felt pens to draw arrows and other shapes to support their ideas. All student discussions were recorded to help the researchers check their understanding of the models while analysing them. If the group of students was large, with between 6 to 8 students, they were split up in smaller groups and asked to make separate models. There were two facilitators present during the workshop: the principle investigator and a research assistant who was well informed about the research and the modelling activities. The facilitators were available for questions regarding the modelling assignment and they asked questions to the students to clarify concepts and relations in the models. They did not interfere in the modelling process.

6.2.3 | Sampling

The sampling procedures used for Study 2 were similar to the ones used in Study 1 with student cohort 2009. All the faculties in DUT have mentor group systems in place. Most students work on their projects in these mentor groups, while at the same time these groups are intended to create support for the students. In some faculties the mentor groups are only intended for support. The mentors are there to support students and help them find their way. We asked coordinators from the mentor programmes to select mentor groups at random. We set up meetings with the mentor groups to explain the research and ask for student participation, and we distributed a description of the research and consent forms to the students. The consent form that was used was the same as the one used in Study 1 and it is presented in Appendix 2. Participation in the research was voluntary. Interviews were scheduled in breaks so they would not overlap with any education activities and lunch was provided. The students who were willing to participate were invited for a group interview over lunch briefly after the first meeting. Not everyone was able to attend all sessions.

We chose to select multiple groups from a limited number of faculties chosen to represent the three tiers, or 'boxes', that make up DUT and to complement these groups with single groups from various other courses to include a wide variety of student experiences. Multiple groups of students from Applied Physics (4 groups) (AP), Civil Engineering (4 groups) (CE) and Architecture (3 groups) (AR) were interviewed. From the following courses single groups were interviewed: Applied Earth Sciences (AES), Industrial Design Engineering (IDE), Systems Engineering, Policy Analysis and Management (SEPAM), Electrical Engineering (EE) and Computer Science (CS). The latter groups were also selected at random from the student population. It was intended that all courses of DUT would be represented in this study, but that proved to be impossible. Mechanical and

Maritime Engineering and Aerospace Engineering did not want to participate. In some faculties it proved to be difficult to meet with mentor groups and as a result there was only one meeting with students from CS and from IDE and SEPAM only one student was willing to participate.

In total 24 students from AP of which 3 were female, 30 students from CE of which 6 were female, 13 students from AR of which 5 were female, 5 from EE of which 1 was female, 6 from CS, 4 from AES of which 1 was female, 1 female student from SEPAM and 1 student from IDE participated. In total we interviewed 16 groups of students in the first round and 13 groups in the second round. There were 4 workshops that were attended by 34 students, 6 of which were female. Together the students produced 10 models for student success.

In Study 2 a number of students left university and again it proved to be difficult to retrace these students. With this student cohort we had taken care to ask the students to provide us with their mobile phone numbers and private email addresses, but even this did not help much. Sometimes students would just stop responding to our emails, without giving any reason. It is unclear if these students had left the university, had just not responded and or had not seen any emails because they may have gotten stuck in spam filters. Phones sometimes were disconnected or simply not picked up. We managed to contact only four students with whom we set up telephone interviews. To recruit more students who were contemplating leaving their course, the DUT Career Centre, which offers workshops on study reorientation allowed us to introduce the study in the workshop and ask for participation. A small number of students signed up, but none of these students answered email or phone calls to set up a meeting.

6.2.4 | Coding

The codes used in this study were based on the codes developed for Study 1 with student cohort 2009, modified slightly based on the outcomes of the literature review and the findings of Study 1. In practice this meant that a few codes pertaining to student backgrounds were added, a code family was created to catch codes pertaining to student dispositions and the study strategies category was enhanced with codes pertaining to study behaviour to allow us to study this particular topic in more depth. All interviews were recoded and transcribed verbatim. In the previous study we coded all text in the transcript to make sure we did not miss any topics and interpretations. In this study we only coded the fragments of text that pertained to one of the codes. There was no requirement for length of a quote, it could be a single sentence or a page-long statement or explanation, but the point of departure was that the text should be about a single topic and be meaningful as a fragment. In practice this meant that if students started to talk about a new topic and then went back to a topic that was discussed previously, the previous topic was coded twice. The fact that students revisited a topic was taken to indicate that they needed to elaborate on it further or to stress the importance of the topic. As in the previous study, we assessed the overtones of the statements and counted how often codes were used. Due to the large numbers of students that were interviewed, it was not always possible to connect statements to a single participant. As a result it proved impossible to connect persons with quotes in the group interviews. The transcripts therefore were analysed on a group level, rather than on an individual level as done in Study 1. The procedure for the analysis of the outcomes of the workshops will be discussed in the section 6.5 on the outcomes of the workshops.

6.3 | Results of the analysis

The focus of this section is on the overall pattern in the data with a special focus on the students' study strategies.

6.3.1 | Perceptions of success and BSA

The coding process resulted in 9 codes: Intentions for P-in-1 and BSA and Feasibility of P-in-1 were mentioned most often: 29, 20 and 17 times. Other codes concerning issues such as planning, intentions and the BSA were mentioned between 4 and 10 times. These codes are shown in Table 6.1.

6.3.1.1 | Intentions for success: progress and understanding

The motivations for students to enrol in a particular course varied: some students had a motivation for understanding and the pleasure of increased appreciation of the topic was the kind of award they sought. Other students had the intention to be successful in a particular field later in life, for their course was something that would aid them to achieve these goals. No matter the personal motivation of a student, passing exams and progression were essentials part of the student experience. Credits represented the consolidation of formal learning in any university course. It is not surprising that all students participating in this research reported in the first interviews they were eager to make as much progress as they possibly could in their course.

A desire for deep learning was mentioned four times. A student of CE said: *"I will try hard, but I'll see it when I get there. It's not that I don't find P-in-1 important, but I want to absorb this education. I want to be able to do it. The diploma in itself is a reason to party, but it's not what truly matters."*

6.3.1.2 | Intentions for BSA and P-in-1: a two stage rocket

In the first round of exams many students reported that they intended to obtain their P-in-1. Intention for P-in-1 was mentioned 29 times. Students said things such as: "*If you can do it, you should go for it.*" and "*Of course I go for the diploma!*" Many other students expressed their doubt as to whether or not it was feasible for them. Some of these students also stated that they would definitely try, while other students stated they aimed to obtain between 40 to 60 credits. Some students saw the BSA and P-in-1 as a two stage rocket. First obtain the 30 credits, once that is achieved, move on to the next target. A student in CE said: "*I focus on the BSA, but I can always try [to obtain P-in-1]. I wouldn't lose any sleep if I do not make that. … If only I obtained 30 credits, that would be disappointing, but once I have 40 credits, I will sleep soundly.*"

In the second round of interviews some students reported they had failed to pass a number of exams and the P-in-1 was no longer an option. A student at CE said: "*Obtaining P-in-1 was not entirely my goal at the beginning of the year. I knew it was not completely realistic for me, but I'd rather set the bar slightly too high than too low.*" Most students, who had not yet passed the 30-credit threshold at the time of the second interview, were confident they would get to 45 to 50 credits. A student at CE said: "*I would like to obtain at least 35 credits, but I will try hard to pass all the tests to come. I am aiming for 45 credits, 60 would be better, but 45 is just as fine.*" A few students struggled to get to the threshold of 30 credits. A student at EE said: "*I would like to pass my maths exams and the BSA. I have conferred with the support officer and if I pass my project, I am getting close to obtaining BSA. I will still have to pass another subject. I had a 5 (out of 10) for Calculus, I will try the resit for that course.*" Other students had been to see the student counsellor to discuss how to mitigate their situation. In most cases they blamed their own behaviour for the lack of progress. They resolved to be more committed and to be more selective: instead of trying to pass all the courses, they started to focus on a few key courses.

A number of students were right on cue with the number of credits obtained. These students continued to pursue their P-in-1 goal. A student at AP said in the second interview: "*My initial goal was to pass the BSA threshold. Now I have obtained 30 credits, I have upped my goal to obtaining P-in-1.*"

6.3.1.3 | Perceptions of feasibility of P-in-1 and BSA

Many students stated in the first interview that they did not believe the P-in-1 was feasible: doubts about its feasibility were expressed 17 times. Students reported that they had heard or read that only 10 per cent of DUT's students obtained P-in-1. A student in Architecture expressed this as follows: "*I happen to find life besides studying and sports important too. You have to accept that you cannot always get an 8 [out of 10]. Sometimes you get a 7, and sometimes you fail. As a result you cannot obtain all your credits or P-in-1. I know this and I accept it, but at the same time I set my own bar pretty high: I would like to obtain P-in-1, but I would not be disappointed if I fail. While I am bringing this up, I think: be realistic, you will not be able to pull this off.*" A student at CE said: "*You are trained at a high level here. If anybody can pass exams here in one try all the time, anybody could do it. It [studying here] shows that* *you are competent. You have had to work for that. You have achieved something."* A student at AP stated their viewpoint short and sweet: "*You know what is fun? Not spending time on your studies. Physics is fun, but it is not a life-style."*

Some students did believe that the BSA was feasible. A student at EE said: "*BSA has to work out. It is only half of your entire course load. You have just obtained half, if you can't do that, you're a pathetic student."* A student at AP said: *"If I obtain 85 per cent of my goal, like 47 or 52 credits, I am satisfied. That is not the P, but still a nice fat percentage. BSA is feasible for me. When you look at it in absolutes, you need to obtain a 6 [out of 10] for half of your classes. If you cannot do that, you're doing something wrong, I think."*

A number of students resent the BSA. They felt it created a lot of pressure for them to perform. They needed to pass their subjects anyway and for them the BSA just added superfluous pressure. They experienced that in the first semester they were overwhelmed with all the things they suddenly had to deal with and they could not control all the factors that were important for achieving success. They resented the idea that they could not continue with something they enjoyed if they failed one exam too many. Some other students brought up that they felt the BSA was not helpful. They knew some older students who still had not finished some first year subjects and they established that the BSA did not solve the problem of senior students who still had not passed a first year subject. These students felt that it would be more fair to students if the BSA was transformed into a rule requiring all students to finish P in 2 years. This would be tougher, as student could be sent away after two years, but it allowed students who were off to a bad start to make up and do something they love. Other students were positive about the BSA. They thought it was right to set some requirements for continuing study for students.

6.3.1.4 | Perceptions of BSA communications

Most students found the letters they received regarding the BSA silly. A student at CE stated: *"I can come up with the idea that if I have obtained 50 credits, I will have a positive advice on the BSA. I don't need to read that in a letter."* Most students mentioned that they already knew what was in the letter and that it mainly served as a means to let their parents know they were doing well. In some cases this led to situations where the parents gave the students a hard time, although these students were doing quite well, the parents knew too little about the context to be able to assess whether their child had done well or not.

Some students were upset because of the letter. Their letters stated that the students were 'at risk'. These students had failed one or more exams, but they did not make a big thing out of it. They were certain they could make up for it, but the letter felt like a vote of no confidence. One student had not received the preliminary advice at the time of their interview, but he had failed a number of subjects and had visited the support officer for advice. He could still obtain the minimum required for the BSA and probably even more than that. He felt the letter would not add anything for him. One student stated that he liked the letter, because it confirmed to him that all his results were properly administered. The letter served as final proof of this.

Table 6.1 | Codes pertaining to P-in-1 and BSA.

		Code applied n times
P-in-1 and BSA		**110**
1	Intentions for P-in-1	33
2	Intentions for BSA	22
3	Feasibility of P-in-1	17
4	The two stage rocket or "as much as possible"	20
5	Desire for deep learning	7
6	Communications on BSA	11

The fact that the topics of P-in-1 and BSA have come up in conversations so often is informative in itself. BSA itself is a policy measure to increase student success and decrease time to graduation by requiring students to obtain a certain number of credits within a set time frame. It has a lot of impact in how students relate to their studies and experiences and to the goals they set for themselves. It seems to increase students' commitment and it helps students to make their intentions for the first year more explicit. In Study 1 it was observed that many students were unhappy with the communications on the BSA. In this study similar concerns surfaced: students believe that the letters with advice are sent at unfortunate times of the year and are redundant. For the students who do not receive positive preliminary advise the letter feels like a vote of no confidence: they tried hard and have good resolutions on how they will try to do things differently, and they feel the letter is unsupportive. We will go into the perceived effects of the BSA in more depth in chapter 8.

6.3.2 | Perceptions of the education environment

The codes and the number of times they were applied are shown in Table 6.2 at the bottom of this subsection.

6.3.2.1 | Courses, curricula and subjects organisation and load

The codes pertaining to course organisation and course load showed a slight overlap, as scheduling and experiences of course load go hand in hand. Both topics surfaced regularly in the interviews. Course organisation covered issues with tight schedules: students often needed to submit assignments for their subjects in mechanics, but occasionally also for maths and they participated in projects that had regular deadlines. They also had to do practical work, especially in CE, AP and CS, and studio work in IDE and Architecture. It was hard for students to comply with all of this, especially because deadlines for assignments were often not harmonized across a curriculum. It also gave the students very short windows within which to get their work done, which fragmented the available time students had to study. As a result, they had very few opportunities to study a particular topic for an extended amount of time, which would have helped them engage for in-depth understanding of the materials, create an overview and see how the topics are related. In addition, students had little to no opportunity to relax, especially in the first semester. The course load was mentioned 31 times and it was the code that was applied most often out of the education environment codes. Students from almost all of the courses participating in this study mentioned it. Students did not always seem to mind, because they were working on topics they often were passionate about. At the same time, the long hours the students had to spend on campus, engaged in all kinds of learning activities wore them out. A student at CE put it like this: "*You spend a full day on your work, you go home to eat, you do some more homework and you turn in.*" Sooner or later most students got behind and started prioritizing their time to deal with whatever was their most urgent assignment, be it a project or an assignment. Student overload on a course was partly a result of an overload of work to be done for that subject. The level and pace at which most subjects were taught was very high and students felt they the number of credits they received for a subject is not always representative for the amount of time they needed to spend on it.

Unclear expectations of the students were reported 17 times both for expectations for exams and for projects. Many projects were deliberately ill structured as a teaching device, but often the expectations of the course tutors regarding the deliverables were also unclear to students. Often these expectations became clear when the students received feedback on their reports, but even that was not always the case. A student at EE told the story of getting useless and childish feedback at both interviews he participated in and both times he was agitated. This type of problem was especially distressing for the students in AR whose first project in the first term was worth 10 credits. They felt stressed not knowing what to expect, how would it be assessed, what kind of feedback they would receive and when they were assessed they were not always happy. On design, one student said: "*It will never be good, but it can be wrong.*" In another conversation the interviewer asked the students in architecture what they felt was expected from them. A female student answered: *"You have to learn to talk like an architect. You have to present your work as if you are not involved and you need to talk about it in the most ambiguous way possible. If you don't have a story as to how you arrived at this design, you just have to make it up."*

Course materials were a source of frustration for many students. Books were boring or so thick that reading them all was simply not feasible for students, sometimes books were inadequate for the needs of the students, either because they did not present the materials in a way that the students deemed helpful, or because an answer key to the assignments was missing. The alignment between theoretical courses and projects should be improved. Only the student from SEPAM was positive about how well aligned the curriculum was for her course, students from CE, EE and AP believed there was a lot of room for improvement in this area.

6.3.2.2 | Perceptions of teachers

Codes pertaining to teachers were used 112 times. A prominent topic was how teachers conducted lectures: for a student a good or a bad lecture usually was like a package: it was bad if the lecture was repetitive, the teacher was uninspiring and the materials were disappointing. When the lecture was good, the teacher paced well, was enthusiastic, used the tools of the trade, the blackboard and PowerPoint, effectively and she or he had a repertoire of how to explain complex things. The teacher for construction mechanics at CE had this figured out: he started with a brief recap of the previous lecture and gave feedback on mistakes made by many of the students in their online assignments. There were other teachers who used a similar approach and it was greatly appreciated. Students at architecture said: *"That teacher had a good and clear story, his intonation was good and that made it fun to listen to him, The PowerPoint was effective too, because the slides fit in perfectly with whatever he was telling."* Some teachers, however, had so many slides that they would loose track themselves, which was confusing for the students. Students prefered it when a teacher wrote along when they explained, but when they did they should not write too small or all over the blackboard. An example of a teacher, who used media in an effective way was given by students from AP: "*This lab teacher, he really enjoys explaining the experiments, you notice it because he is so enthusiastic about it. He shows short videos on a large screen and then something unexpected happens. Something freezes over, or something. It is up to us to find out what happened there with the information that is available in the lab. It's good fun and you really grasp what you are working on.*"

Students from AP reflected on the second term: "*… We mostly had good teachers this semester. [Good teachers] are clear and have a good pace. They approach things differently [from the book] and know well which topics need more attention and which topics are evident. … The guy who taught [subject name] was not great, I mean, he explained really well, but it was a tad boring.*"

If students felt that a teacher was merely telling them what was in the book, most stopped going to the class and switched off. Teachers who used exactly the same set up for each lectures in a term and never varied, were also perceived to be boring and bad. Some students were more forgiving and recognized that teachers were not perfect, and could still contribute to their learning process and these students continued to go to lectures. A student at EE enjoyed a certain chaotic teacher because it forced him to pay attention, but all the other students preferred teachers who were well prepared, i.e. able to tell their own story not just the one in the book, structured and had an understanding of what the students needed. Issues with classroom management came up 16 times. Most of these statements had to do with audibility of teachers. Some spoke too low, slow, inarticulately or very monotonously. At AP there was a teacher who was seen to be rude in his dealings with students and students of CE brought up the fact that one of their teachers would interrupt him or herself often to make hissing sounds to indicate it was too noisy to his or her liking. The students found this annoying, because in a large lecture theatre with over 200 students there can never be complete silence. Strict teachers were not perceived negatively: at AES there was a teacher who required students to be there in time and she was not nice to the people who came in late, but the students felt that she had a point. Using the tools of the trade well, and enthusiasm were considered to be of the utmost importance when judging if a teacher was good or not. Teachers who were enthusiastic about, potentially, boring topics, could still engage students and motivate them to take part in the learning process.

Teachers in the practical and project sessions were held to a different set of standards, for such teachers it was most important that they clarified what was expected of the students, gave constructive feedback, were prepared for the kinds of questions students had and that they were available during the session. The studio work in AR and IDE was very new to students: they had little to no experience with design or with working in such an environment, their assignments were ill structured deliberately to create room for creativity and it was often unclear to the students what the assessment criteria would be. A good supervisor was essential for students to learn how to deal with these issues. Vague feedback created frustration. In some cases teachers were not prepared to explain to students why they believe something was bad. Some teachers managed to give honest and constructive feedback in a way that did not intimidate students. Two groups of students from architecture were not very happy with their supervisors because of low quality feedback, but they did recognize that the teacher helped them to stay on schedule, and that in retrospect, they learnt a lot about how their supervisor approached the concept of design. Students in EE complained about the teaching assistants who could not answer seemingly basic questions in a practical session. They would have to ask the teacher who was in another building and often came up with the answer that they would have to confer with the course teacher to get an answer and would get back to the students in the next class. Another peeve of students arose when there was too little support for practical sessions or the support staff was seen to be too busy doing something else.

6.3.2.3 | Assessment

A large part of student life evolved around the exams. Students spent the entire term preparing for their exams and exams represented credits and progress and as such, they

served as an important measure for students' success. It was no surprise that the students talked about exams a lot during their interviews on their experiences in university. Students would say little when they believed an exam was too easy, although they would feel cheated if the exam was easier than the 'exam' they had prepared for or if the exam was not representative of the subject matter covered in the examined course. In a conversation with students from CS the following was heard: "St1*: I failed the exams, those diagrams did me in. I didn't study that topic, but it made up 60% of the grade.*
St2: That was stupid: we only treated diagrams in the very last week of the term, and it constituted 60% of the test! A lot of people went south as a result.
St3: I noticed it in the old exams: there was a sick amount of points awarded to the questions on diagrams. So I studied on them really hard.
St2: How did you find out how they work?
St3: I looked at his slides. It wasn't very clear, but with some logic I worked it out."

A student from AES said: "*The exam of [name subject] was identical to the old exam for about 90%, so it wasn't too bad. But come to think of it, that's actually really bad."* In the first round of exams students many students failed because they believed they had mastered the materials, but found out that in reality that they had not. One student failed an exam, because he believed he had 3 hours to complete the test, but it turned out he only had 2 hours. This variation deviates from the normal duration of exams at DUT.

Many courses, especially the ones in mechanics, have a system of weekly compulsory online assignments, if the students failed more than a certain number they were automatically excluded from taking the associated examination. The online assignments were intended to help students master course material and to help them prepare for exam. Students mentioned that studying these assignments was not enough to pass an exam, they advised that if you wanted to do well in exams it was also a good idea to study past exam papers because the online assignments put things slightly out of their context. Some students had to learn this the hard way.

From the 10 statements on project assessment, only 1 was positive. That was a statement by a student from architecture who received a high grade for her project. The other statements were all about negative experiences with project assessment. At AP in one of the projects participants received grades based on their perceived participation in the group work. This was judged solely by the student assistant who supervised the project. Some students felt that they were judged unfairly and they felt upset because they could not appeal the decision. The students at architecture had issues with project assessment. They found it hard to deal with feedback that was positive one day, and negative the next. Sometimes the feedback was seen to be contradictory. The assignments were graded by a panel of judges, but that made it extra hard for the architecture students to judge whether or not they would pass.

Table 6.2 | Codes pertaining to the education environment.

		Code applied n times
Education environment: organisation		**58**
1	Course organisation in general	22
2	(Un)clear expectations	17
3	Issues with course materials	11
4	Alignment between courses and projects	8
Education environment: load		**45**
1	Course load in general	31
2	Subject load and disproportional numbers of credits	14
Education environment: teachers		**112**
1	Lectures: Structuring, explaining and pacing	+: 30 - : 23
2	Lectures: Classroom management and audibility	16
3	Lectures: Using tools	5
4	Practical sessions and project work: preparation and availability	10
	Practical sessions and project work: feedback and expectations	14
5	Enthusiasm	14
Education environment: assessment		**38**
	Exams	28
	Project assessment	10

These outcomes show many similarities to the outcomes in Study 1. With regards to the organisation of course, curriculum and subjects, students again bring up issues of lack of clarity in expectations and issues with course materials.

This time lack of information did not surface as a separate topic. Alignment between courses and projects is a subcategory of 'general course organisation'. It was brought up several times at CE, SEPAM and AR and continues to be a concern. The code pertaining to course load was applied most often: overloaded curriculum is an issue that will not just go away and that all new students struggle with. Many students feel that the course load is disproportional to the number of credits awarded for subjects. This clearly has to do with perceptions, but it would be something that could be verified with studies where students are asked to log the time they actually spend on each subject. If students mention the topic of overload disproportionally as they do, this should be something course management needs to concern itself with. Students who need a little more time to get settled in or who need time to realise they are not in UPE anymore and adjust their behaviour accordingly, are set back in a way that they cannot make up anymore. They are forced in a survival mode early on, because they need to pass the 30 credits threshold if they want to continue their course. From this subsection it is clear that there are relations between the perceptions students have of their educational environment, their dispositions, and their behaviour.

6.3.3 | Perceptions of the social environment

We used three codes pertaining to the students' social environment. 'Peers' refers to all the statements on interactions with fellow students and includes interactions within the study association, 'friends' is about interactions with people students hang out with besides their study cohorts, e.g. flatmates and school friends. 'Fraternity' deals exclusively with interactions at a student fraternity. The codes and the number of times they are applied are shown in Table 6.3.

Peers play an important role in the lives of students. Students appreciate the mentor groups that are formed at the beginning of the year and that double as project teams in the first year. This is a great way to meet new people, to have a structure and to get to know each other. A student from EE was part of a group that quickly disintegrated and he was assigned to another group: *"I was assigned to this group that was already really close. They already knew each other well and they were in the fast lane with the project. I had no idea what was going on, so I volunteered for the soldering. I felt shitty, but slowly it got better and suddenly I was in the centre of the group. Now these people are my friends."* Often people befriend each other in these groups. Students quickly form private groups of friends that they hang out with in the lectures and whenever they are on campus. Sometimes they also study together. In the Netherlands the study association is am important feature of the faculty social environment. Most associations have their own bars in the building, they organise many course-related events and they are a focus point for social activities. In the case of EE the association is the only place in the building where there are couches to kick back and hang out.

Friends are also important, although many students tend to get out of touch with their school and pre university friends. This is especially the case when students find housing in Delft and do not go home often. Their old friends usually are also studying and have their own lives and new sets of university friends. Flatmates are a source of support and of distraction. Flatmates know what is going on, they can help with problems such as tricky maths assignments, and open up all kinds of opportunities to new networks and events. The downside of flatmates is that one first needs to find a house to live. In September when the academic year starts, many new students are looking for an affordable place to live and it is not easy to find a place right at the beginning of the academic year. One student from EE shared that she had been out of luck and needed to commute 3.5 hours a day in the first months of the year. This had been very hard on her and she felt it was one of the reasons why she had had trouble adjusting to the new study environment. Family was also coded under the 'friends' code. Few students brought up their families, but a female student from AP did because her family was a source of concern for her. She lived at home and her parents were not supportive of her studying with mainly male students. She was expected to do chores at home and she had trouble creating a quiet environment to work on her assignments. Although it only concerned one student in this study, she is probably not the only student in the university who also needs to negotiate at home about the conditions with which she has to deal.

The fraternities are another source of support and distraction. Fraternities are mainly about social activities and often student members are required to attend a fixed number of times in the week. They come in many flavours, some are traditional in the sense that they require members to show up regularly and drinking beer is considered to be the norm. Other fraternities may have a religious affiliation and offer a different kind of activities. There are also sports associations that double as fraternities, especially if they have their own bar. Fraternity activities take up a lot of time, if students are not careful fraternity membership can cause problems, but can also be a great source of support and access to older student who have been there and know how to get out of a problem. Associations are considered to be an important part of Delft student life and it is difficult for students to meet people outside their studies if they do not belong to an association. A student from CE who was a member of the large, traditional fraternity said: "*I find it tough in this first year: I need to pass my BSA, but I don't want to give up my frat. My club meets at least once a week, and I find that I do less for my studies in the weeks I go there more often. But it's not just about the beer, it's also the conversation, the fun and support. And if I fail my BSA, I will have to let go of this too.*" Something the students learn in their social environment is how to navigate through their courses successfully. The university is unknown territory for first year students, finding one's way is not always easy and the requirements of courses and subjects are sometimes contradictory. Students often are helped with learning by learning from the experiences of those who have gone before them and came out the other side of the first year. The social environment serves as a support system for students to hang in there and continue to focus on their studies, but it is also a support system that creates opportunities for students to relax and expand their horizons, either over a drink, in a peer group studying or practising sports. It seems that the social environment does not have a direct influence on success, but it helps in creating conditions for success.

Table 6.3 | Codes pertaining to the students' social environment.

		Code applied n times
Social environment		**55**
1	Peers	30
2	Friends	14
3	Fraternity	11

6.3.4 | Motivations and study behaviour

Effective study behaviour and the motivation to keep up this behaviour up are important for student success. Study behaviour for this research consisted of the time students spent studying and on the strategies they used while studying. Study strategies do not normally come out of nowhere, some students bring successful strategies with them from UPE, most students discover that their old ways do not work in the new environment and try to develop new strategies that work for them. Some are more successful than others when it comes to developing such strategies. The codes used to analyse this topics and the number of times they were applied, are shown in Table 6.4.

6.3.4.1 | Motivation

The code for motivation was used 31 times. The code pertained to the principle of 'if your are in for a penny, you are in for a pound', by which the students meant that if you decide to study a particular subject, you need to hang in there, also when it gets tough. A student from CE said: "*You came here to study, so you need to do that before you go out to have fun. If you have chosen a course, it is a lot more motivating to do the work it requires.*" The student from IDE said: "*I have to work really hard for this, but I don't want to let that stop me*." Keeping up the courage pertained to the practical side of staying motivated. A student from CE said: "*If occasionally you do something else, you are more motivated when you get back to your studies. You need to do something completely different, it's the variety that keeps it doable.*" Many students had the experience that success led to more success and a lack of success is demotivating. In general the students were positive about how interesting they found their courses. They found their courses engaging and they were enthusiastic about what they do. Most students enjoyed the combination of the theoretical and the practical sides of engineering. A student at EE said: "*It is getting so deeply into the heart of the matter, it gets incredibly engaging. It is all finally coming together*." At the same time, many students remarked that not all the projects they had to do were are meaningful or well timed, and that the course load was overwhelming. The various course subjects were generally appreciated. Students seemed to enjoy their courses when they could clearly see the connections between the subjects, and between theory and application. Many students had problems with their maths subjects: the students did not mind tough courses, as long as they were feasible. A student CE said: "*I really like Dynamics, it has a strong relation to the course, and you really have to make an effort. It's cool when you get it. If I didn't get it, I wouldn't enjoy it.*" Not all is right, at CS a student said: "*There are so many courses that don't amount to anything, namely every course that is taught by [name of teacher]. [Name of subject] is a subject consisting of all the left over bits that could not be fit in anywhere else.*" A student in AP said about a project: "*I kind of like it, you are doing all kinds of physicsy things, with designs and you read about stuff. But in all honesty, this subject is silly.*

You have to come up with design that you can never test, so you just have to assume it works. It is fun to do something practical, though."

6.3.4.2 | Study behaviour: time spend on task

This code pertained to two sub codes: actual time-on-task and effort. The first code dealt with how much time students spent on activities that had to do with studying: commuting, going to lectures, working on assignments. A topic that was part of almost all the statements, was that students experienced a lack of time to do everything that was expected of them. Some students reported they felt it was impossible to do everything their teachers ask them to do, another student said that he found he could concentrate on his assignments for about 6 hours a day and that was not enough to cover all material by far. Effort was applied as a code 19 times. This code was used to indicate how students decided what was worth the effort and what was not. Although teachers believe that all assignments were important, students quickly find out that this was not the case. Students usually found assignments that helped them grasp fundamentals were worth the effort. Students also tried to create circumstances that helped them to focus so their efforts were not made in vain.

6.3.4.3 | Study behaviour: planning

A strategy that students found useful, and one that was often advised by student counsellors, was to plan workload. The first subcode of planning was 'learning to plan'. This code covered students who never had to plan, but who were adopting it in their repertoire of strategies. A student from AP said: "*So I sat there in the exam room and I realized I had forgotten to study this one topic. Suddenly it popped in my mind that I needed to get organised so I knew what I needed to study and stay on top of it."* For many students the question was whether to plan or not. It came up in conversations 15 times. Some students knew that maybe they should plan their activities, but they somehow did not get around to do it. They performed better under pressure and let the pressure build until the exams come. They said they hated themselves every time it happened, but as long as they passed their exams this way, they did not change. Other students started planning their time when they noticed that they were not doing well in a subject. Other students were comfortable with this way of working because they already knew it worked for them. A female student from AR said: *"I always make schedules for myself. I make a table with all the subjects I take and with the days I have available. I indicate what I have to do when. I divide my time equally, unless I find out that there are subjects I need to devote more time to. Then I reorganise the schedule. I invented this methodology in UPE, and it has served me well."*

6.3.4.4 | Study behaviour: strategies for studying

The strategy that was most often employed, or that students wished they could employ, was to stay on top of the subject matter and materials. Keeping up came in various flavours: some students prepared for all their lectures and kept up with their assignments, some students kept up with the assignments and went to lectures. 'Going to lectures' could be viewed as a subset of 'staying on top', as was the 'part exam strategy'. Many students went to lectures to keep up with the subject matter. In the best possible scenario there was an excellent teacher who explained well and turned boring topics into entertaining ones. In the worst case the teacher was not inspiring and did not explain well. Most students would probably not go to such lectures and prefer to study by themselves, although some students would still go, because at least they had been exposed to the topic. Another way of keeping up was to take part in part exams or assignments that were graded and counted towards the final grade for a subject, when available. As one student in CE explained it: "*See, I make all these part exams, because that grants me an extra resit: if I fail my part exams, I can give it another try at the regular exam. I see that as my first opportunity to resit the exam.*" Other students did the next best thing: they kept up with lectures and some of the materials and did just enough to maintain control, but they relied on the lecture free weeks prior to exams to catch up. Some students worked more or less randomly and prepared for their exams at the very last moment. These students often brought up that they lacked discipline. Breaking bad habits like these was not easy for some students. Even if they knew they were not doing well in their course, they still became sluggish when they should be studying. Other students procrastinated, but found ways to improvise and get away with it if they studied at the last minute. The code 'finding a strategy that works for you' included 19 statements in which students described their process of developing strategies that worked for them. This code partly overlapped with 'learning how to plan' discussed in subsection 6.3.3.3, however, we used the planning code when the outcome of the student's story was that they needed to plan better. In this strategy code we included the statements that tell stories of developing more generic study strategies. In all cases finding a way to continue to work hard was essential for students, but how they got there was different for every one of them. For some students studying together in groups was effective, for others it was working at home and taking occasional breaks with flatmates who could explain advanced topics. A student from architecture had booked a holiday in the autumn break, only to find out that week was scheduled right before exams and was not intended to be a break. As a result, he failed an exam which added to his study load and as a result, he needed to change his entire way of studying to be able to combine his new subjects with his resit. A student at EE said: "*I will have to resit exams from the first terms. I will need to study even harder. I have already started. I checked [with the teacher] to see what I had done wrong and I found that I was very unstructured. I skip certain steps and I loose points as a result. That is something I specifically need to focus on now.*"

A number of popular study strategies emerged from the transcripts. A popular strategy was to make use of old exams. In DUT many previous exams for subjects were available online and students used these to prepare for their coming exam. Students took these old exams as a gauge of the level and topics that were likely to be included in the new exam. Some students used old exams as a self-test after they had covered specific material; others mainly studied the old exams as a preparation and hoped for the best. The third strategy was one used mainly by students who had failed exams. It was hard to combine new subjects with studying for resits and many students decided to drop subjects in favour of a resit that was considered to be of greater importance. Mechanics was usually high on the list of subjects where procrastination should be avoided, because the follow up mechanics subjects are built on prior knowledge. A student from CS said: "*Calculus, you know, I just didn't get it. I spent tons of time, but I could not get my head around it. I decided not to sit the exam and spend my time on other subjects, you know. I pulled out my books again when I had time on my hands and just chilled out. Now I get it, so I will continue to study it for the next few weeks and when the resit gets there, I'll just review it one more time.*" In architecture there were large projects in the first and third term, as a result the second and fourth terms had a high exam load for theoretical subjects. Students who failed their exams in the second term, often dropped their project in the third term, because they wanted to obtain as many credits as possible from the resits to pass the BSA threshold.

Table 6.4 | Codes pertaining to motivation and behaviour.

		Code applied n times
Motivation		**100**
1	In for a penny, in for a pound	11
2	Keeping up the courage	9
3	Success creates success	11
4	Expectations of interest in course	25
5	Expectations of interest in subjects	44
Behaviour: time spend on task		**39**
1	Actual time-on-task	20
2	Effort	19
Behaviour: planning		**20**
1	Learning to plan	5
2	To plan or not to plan	15
Behaviour: strategies		**114**
1	Staying on top or the next best thing	25
2	The 'attending lectures' strategy	21
3	The 'part exams' strategy	20
4	Breaking bad habits	8
5	Finding a strategy that works for you	19
6	The 'old exams' strategy	12
7	The 'postponing exams' strategy	9

It is not surprising that motivation and learning strategies have come up so many times in the interviews: in an overloaded curriculum students need a lot of motivation to keep up the study behaviour necessary to be successful in such conditions. It is paramount to students to develop effective study strategies that allow them to cover the materials and understand them well enough to pass the exams and to have enough background to understand the courses that build on the students' prior knowledge and to spend the time they need to achieve their goals. Some of the strategies are instigated by how the education is organised. In the previous section it was brought up that teachers have some influence on how students study and this is reflected in the 'attending lectures' strategy. By offering opportunities to take part exams or participate in assignments that count towards the final grade, teachers inspire behaviour to stay on top. Students prefer these part exams not to be mandatory, because it takes away control when students already have little control over their situation and time as a result of the busy schedule. This sense of not having control tends to create more stress. The old exams help students to gain a little more control, as these exams help clarify what is expected of students on the exam.

The strategies that surfaced in this subsection overlap, but students often use more than one of the strategies discussed. Some students have trouble breaking their bad habits and tend to do so only when it becomes the last resort to achieve their goals, i.e. to obtain enough credits to be able to continue in the second year. Often, through their sluggish behaviour, they are forced in a survival mode just like the students who are off to a bad start for other reasons.

6.4 | Non-persisters on their success

We interviewed four non-persisters over the telephone. The interview guide for non-persister interviews used for Study 1 was also used for Study 2 and it is presented in Appendix 2.3. The interviews were not recorded, but the interviewer wrote reports directly after the interview. The interviewees were 3 males and 1 female, the males were from the courses AP, CE and IDE. The female student was from AES. In this case all the statements can be attributed to a single person. We changed the names of the interviewees into the following names. The student from applied physics was called Henry, Clark came from civil engineering, Isaac left from industrial design engineering and Susan dropped out of applied earth sciences[14].

[14] Through a side project the researcher spoke to a former IDE student on the phone. This student had been forced to leave IDE as a result of an impairment he had and he was very negative about his experiences at DUT, as it had proven to be impossible for him to study successfully in a course with very tight schedules and many deadlines. He had been in close communication with the counsellors before and during his studies, but in spite of that he was often held to the same standards as the regular students, which created a lot of delays and major frustration for him. The university is required by law to create conditions for impaired students to be able to study, but the student claimed little to nothing had been done for him, partly because the schedule of IDE is very unforgiving for anyone who does not fit easily in the IDE mould. We did not verify this story with officers from IDE, but we take it as an indication that impairments are difficult to combine with a course in DUT. This story was in line with experiences with learning impaired studens the researcher had when she was involved with the Board of Examiners at one of DUT's faculties.

6.4.1 | The proportions and level of maths and mechanics

Henry and Isaac ran into trouble due to the proportions and level of maths in their courses. Clark had no trouble with maths, but rather with mechanics. Henry said: *"I had a different idea on the level and proportion of maths in the course. It went fast and you needed a lot of discipline. The depth to which you needed to understand it, was more than I had imagined."*

Henry passed all his exams in the first term, but struggled in the second term when he found that the proportion and level of maths required for his course stayed the same. He did not want to keep up the study regime needed to be successful. He sat the exams of the second term, but quit the course right after that. He said: *"Although I was not very certain I really wanted to do physics and I felt a bit doubtful from the start, I wanted to go for it and give it a chance."*

Isaac had grappled with maths at UPE and passed his exams with a 6 out of 10 by putting in a lot of effort and by often asking for help. Many people had told him that he would make it in university because of his dedication. Isaac found that the maths in IDE was much harder than he had ever imagined. He went to seek advise from the student support counsellor, but he felt the counsellor just passed it over. Isaac said: *"I know people who had a 6 in maths in UPE and who pass their IDE exams with flying colours and I know people who had an 8 for maths in UPE and fail epically. It's just impossible to tell what will happen once you are here [in IDE]."* In addition Isaac found that he was not good at drawing. It seemed challenging and fun in the beginning, and there were no prerequisites for this skill, but students were expected to be able to draw well pretty early on in the course. Drawing took Isaac a lot of time and he found that it did not really appeal to him as it did not come naturally. His results in drawing were poor, while he spent a lot of time on it. Isaac said: *"At the end of this year I have 45 credits, but I failed maths and that will still be there next year. I want to pass things the first time, I don't want to resit tests, but it just did not work out this year. I might give the hard things another try, but I do not think I will ever use those skills ever again. That makes it unfeasible and unattainable for me. There is nothing left in this course that is appealing and challenging."*

Clark was off to a good start; he was enthusiastic and enjoyed the teachers' stories and explanations. This slowly deteriorated, which Clark did not notice at first. He especially enjoyed the design and maths courses and passed his exams without any real trouble. At UPE he had passed his maths and physics subjects without any real effort, but maths had always been his favourite subject. Physics was okay, but he cared more for topics such as radio-activity than for mechanics. Clark did not enjoy statics, but dreaded dynamics and fluid mechanics made him cringe. He devoted a lot of time to the subjects, he went to all the lectures and did all the online assignments, but the subject drove him up the wall.

6.4.2 | Focus of the course

Susan quickly found that she felt more attracted to the subjects where one could study the phenomena of the earth rather than the subjects related to mining engineering. On the open day for parents she found that her father was much more enthusiastic about the course than she was and that made her wonder about her choice. Henry found that he was less passionate about technology than most of his peers and he felt the course did not focus on people enough for his liking. In the second term there were two courses that were supposed to make a link between physics and people, but the main focus of those courses was still the physics and not the humans. Henry felt that if this was all there was to physics, he did not want to do it. He brought up that he had always wanted to study physics without clearly knowing why, but he also never looked into other options for study. He tried applied physics and found it was not for him. Isaac was put off by the woolly, visceral and vague side of IDE. "*In this subject you are released and expected to find your creativity within you, you need to turn something very vague into something concrete. Turn a lump of clay into a shape and the shape into a product. You cannot learn to be creative, you need to have that in you, otherwise it's not going to happen for you."*

6.4.3 | Transition to university

Susan, Henry and Clark also brought up their difficulties with adjusting to university. For Susan the biggest trouble was the switchover from living in a small town far away from everything to moving to Delft. She missed her parents very much and it took a lot of time to get back home. Family members had often asked her if she wanted to study in Delft, AES was her second option after architecture, but on the open day she found architecture not technical enough. She felt comfortable at AES and liked the focus on the earth. After the Delft open day, she did not visit any other universities. Henry had trouble adjusting to the way the lectures were taught. It was different from what he was used to and from what he had expected. Clark said he had trouble with getting used to the freedom of a university and the necessary independence. *"You really have to do it yourself, every last little bit of it, and I did not find that easy."*

6.4.4 | Social life in DUT

All the students brought up aspects of the Delft social life. Susan found that the social life in Delft revolved around the associations and fraternities and she signed up for a sports association. She liked the people a lot and she got on well with her flatmate. She felt comfortable to discussing almost anything and they often had dinner together which gave her a homely feeling. She did not have many friends at university, except for one female AES student who quit and moved back to her parents. That was tough on Susan, although after this she managed to get acquainted with other girls in the course. Clark also had some friends in the course and because of them coming to the faculty was still fun for Clark. Clark lived in Rotterdam and liked that city much better as a student city than Delft. There is not that much going on in Delft, if you are not a member of any association. Isaac liked his flatmates and his fraternity and he regretted that he had to let go of these aspects of Delft student life. This was a reason for him to look to do another study at Leiden University, which is close to Delft. Henry did not like his peers very much. He felt they were too narrowly focused on physics and did not socialise a lot. He did have a good connection with some people and he thinks he could have become friends with them, but in general he did not click with the people het met in Delft.

6.4.5 | Critical incidents

Susan got off to a bad start. She fell at a party in the first term, and fell on her head, the resulting concussion prevented her from being able to study enough in the first term. The exams did not go well for her, for example she registered for the wrong maths exam, but she only found out when she got there, then she found out she could not sit the correct maths exam during that term. In the second term she sat three exams, but she withdrew from university before she had got the results. For Isaac the first course was critical: it was taught by a non-native English speaker who was difficult to understand. It was not an easy class and new terms were introduced weekly. It went very quickly and Isaac felt lost and left to his own devices. The practical sessions went too fast for Isaac, so coming to class became frustrating, because after each sitting you still had to do all the work at home: "*either you are behind or you don't get it.*" Clark worked very hard to pass his mechanics exams, but failed every time by a few decimal points. *"With mechanics you really need to master the theory as well as the applications. I simply do not know how to get a pass for this subject, nor do I know how to apply the abstract knowledge. I lack the insight to do this and here in Delft you need to have a very thorough grasp of the subject matter."* Clark felt overwhelmed with the amount of things that needed to be done: there were lectures on all days of the week, there was a ton of homework and at some point Clark could no longer find any concentration or motivation to study. In the spring break Clark evaluated his options: at that time he had obtained 15 credits, so BSA was still an option, but he was delayed to the extent that he would need at least four more years to finish his bachelor degree and he would have to work very hard. For Henry the critical incident that led to his leaving DUT was his disappointment with the two subjects that were supposedly aimed at the interaction between humans and physics.

6.4.6 | Reflections on not persisting

The two topics standing out in these interviews were the bad choices these students made regarding their courses and their feeling of loss and lack of support. Henry had doubts about physics from the start, Isaac had a poor track record for maths in his previous training. Henry, Isaac and Clark had all not familiarized themselves with the level and proportion of maths and physics in the courses they chose to study before they made their choices, and Susan could have explored other options to study geology if she had not made the assumption, without looking anywhere else, that Delft would be the right place for her. The same goes for Henry.

Henry, Clark and Isaac all had trouble with the level of the course. They all three state that they felt they would not be able to keep up their required study regimes for another few years. Only Clark mentioned his inability to grasp mechanics, Isaac and Henry only mention that they had to work really hard to be able to pass the maths exams. In Study 1 we observed that very few students, and only those who had failed at some point, brought up the topic of aptitude. It seems this observation also holds for Study 2. Susan may or may not have had a lot of trouble with the level of her course, but she got into trouble with her academic work as a result of the concussion she suffered after her fall.

Another thing these students shared was the experience of feeling lost and unsupported. Susan lost a friend who left Delft and her course, and had to call her parents to help her after she fell at a party. She did not have a support system in place at the time that allowed her do deal with and overcome the problem without parental help. Clark and Isaac felt lost and overwhelmed because they felt unsupported while adjusting to the rigours of the engineering curriculum. Another issue for Isaac was feeling lost between the demanding maths he had to do and the woolly and visceral demands of the design projects. Henry felt lost because he felt disconnected from the people around him. Henry and Isaac checked in with the student support counsellor, but they both felt they were not getting the support they needed. Isaac felt his maths problems were glossed over and Henry wanted to discuss his experience of feeling disconnected, but was sent away having been told that he should try harder and look further. On a positive note, all four of the students intended to start new courses after their experience at DUT, and Susan and Clark had already found courses that they were looking forward to starting[15].

6.5 | Results of the workshops

The setup of the workshops was introduced in subsection 6.2.2. The students worked in small multidisciplinary groups and were given a basic modelling assignment. They had to brainstorm about factors and variables, that influenced their own or their peers success and use these to create a model with 'success' as the output variable. All the ideas from the brainstorming session had to be included in the model, but ideas could be taken together if they essentially came down to the same thing in the minds of the students. From each variable, at most, two connections could be made to other variables, the number of

[15] The fifth non-persister who participated in a side-project to this research, had to leave because it turned out to be impossible to study in the IDE curriculum for his as a result of his impairment. He ended up with accumulated student loans. We have not spoken to any other student who had any kind of impairment that got into the way of his or her studies.

connections going to a single variable was not limited to any number. The discussions among students were recorded and transcribed and the transcripts used to interpret the models.

6.5.1 | Method of analysis

The models that the students made looked like flow charts, as can be seen in Figure 6.1, in which one of the models made by students is shown, some of the boxes are linked together.

We analysed the models as follows: for each model we counted the distance between the output variable and the input variables. In Figure 6.1 for instance, the distance between 'Attending and keeping up with lectures' and 'Student success' is 1. The distance between 'Periodic assessment' and 'Student success' is 2. Some boxes are linked. We assumed that this means that the students believe that these variables belong together somehow and we counted the distance for all these three variables as 2.

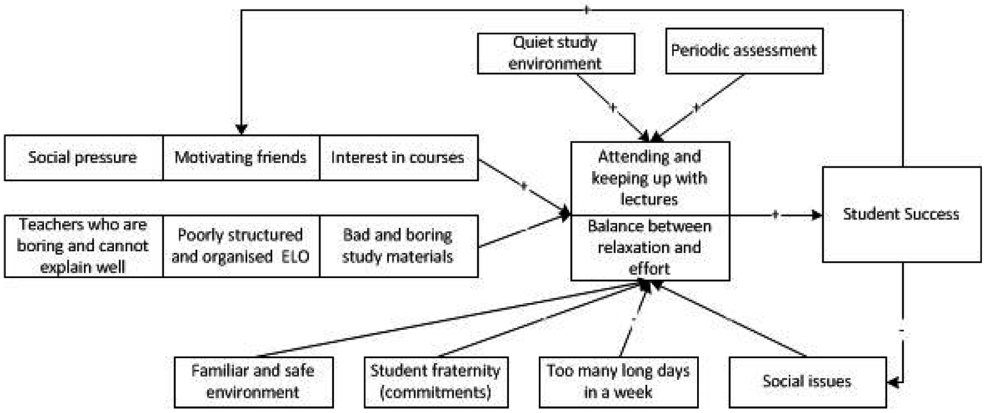

Figure 6.1 | Student model by 3 students.

We disregarded any loops in the model, in this case the two arrows that go from 'student success' to 'social issues' and to the linked variables of pressure, friends and interest. We chose to do this, because student success was intended as the output variable in the model. We repeated this process for all the 10 models and counted the frequency a variable was one, two or three 'arrows' away from the output variable. Next the variables were clustered into: curriculum organisation, teachers, social environment/support, study behaviour, student disposition and facilities. The frequencies for these variables are reported in Table 6.5.

Table 6.5 | The frequencies of distances of factors to the output variable 'Success' based on 10 models.

Frequency distance 1	Frequency distance 2	Frequency distance 3	Variable description
Curriculum organisation			
4	1	3	Balance between study and relaxation
5	3		Quality of study materials (accessibility, availability)
Teachers			
3	5	2	Motivating teachers (who keep you alert and who explain well)
Social environment/support			
1	5	2	Fellow students and flatmates for support and motivation
1	2	1	Fraternity and study association for social contact and continuity
Study behaviour			
4	2	1	Making a planning and sticking to it (discipline)
Student disposition			
1	4	1	Interest in the subject and coursework
Facilities			
2	4	2	Quiet work environment without distraction

6.5.2 | Interpretation of the outcomes

The most important issue for students is balance between study related activities and leisure. As is the case with many engineering curricula (Sheppard et al., 2009), Delft students experience their curricula as overloaded. They feel strongly about having enough time to do other things besides studying. Having a variety in activities to do and time to do nothing helps student stay motivated to do their course work. The curriculum load places a high demand on students at DUT and in response the students have high requirements for their study materials. A student explained this in the workshop: *'You don't always have the time or energy to attend all the lectures. You must be able to understand the materials without any help from a teacher.'* Accessibility of materials is another issue. Students do not want to have to spend time finding out what materials they need, although it is often not clear to them what they should use for studying. This information should be made clear from the study guide or from the course page in the electronic learning environment, but apparently it is not so easy for students to find the relevant information.

The teachers score high on Frequency Distance 1 and 2. Teachers who keep students involved in the course and who can explain material well, and in a structured and well-paced fashion are viewed as important to student success. Teachers who explain well help to save time when students are studying the relevant study materials, working on assignments, etc. Such teachers help students stay motivated, because the feelings of students when they understand the subject matter are given a boost. After all, the students came to DUT to learn about a topic they love. Some students report having trouble with staying focused during lectures, there are many lectures to attend and they take up a large portion of a students study time. Teachers who find ways to keep students engaged and sharp, are much appreciated. There is no single way for a teacher to achieve this, but success seems to centre on creating a dynamic environment where students can sometimes sit back, and sometimes are invited to be fully involved in what is going on. Some teachers achieve this by telling a good story, others intersperse their classes with videos of examples or tell personal stories to exemplify the subject matters. In any case enthusiasm for the topic and for teaching are a big help.

Another source of motivation are fellow students, for instance in project groups. This variable was given the Frequency 2 in most cases, by which we interpret that students view this as an indirect variable. It is not the most important thing, but rather an important support point. Peers in project groups often help each other with issues in their courses and a good peer group helps to keep up motivation. Students also mention that fraternities and study associations are important for continuity. A weekly meeting with friends helps to structure time when students are off to study for exams and in weeks when the schedule is very busy.

Study behaviour is an important factor according to the students, especially with respect to planning their work and sticking to their planning. Due to curriculum overload students need a study regime, and they cannot afford to loosen it up. There is little leeway in a DUT curriculum to catch up. This ties in with the curriculum organisation factors. Students also observed that without interest in a subject it is hard to stay motivated and to muster energy to sit down and do the coursework. Finally, the students mentioned the facilities available to them. They found it important that they could study in a quiet work environment where they would not get distracted.

In much of the research on student success most variance is explained by student related variables, such as aptitude and motivation, as we presented in chapter 3. The students in our Study 2 workshops indicated that, mostly, curriculum related variables influenced their success directly. It is possible that for these students variables such as aptitude were a given or that they simply believed that effort was more important than ability, which would be in confirmation with the outcomes of Study 1. Another explanation could be found in the attribution theory of motivation. The basic premise of attribution theory is that when students believe that their academic achievement depends on controllable factors, they are more motivated, and generally achieve at higher levels, than when they feel a lack of control over their own learning (Pintrich & Schunk, 1996; Urdan & Turner, 2005). It remains unclear why variables such as aptitude are not included in any of the student built models.

6.6 | Contributions to a preliminary model for DUT first year student success

Study 2 has provided us with a lot of rich material to serve as input for the preliminary model of student success. We collected narratives from a large number of students, from many different courses, on their experiences and perceptions of student success in the context of DUT. We asked the students to show us what relationships these variables had in their opinions. We spoke with non-persisters on their experiences and reasons to leave and we obtained models where students showed in a clear way the relationships between the variables they deemed important for success.

6.6.1 | Outcomes of this study

Study 2 was a replication of Study 1 with the aim of answering the same research question: Which variables are related to success for first year engineering students at DUT and how are these variables related?

The intention of this study was to validate and complement the findings of Study 1 using a larger group of respondents representing a wider population of DUT. We used an adapted version of the codebook to analyse the interview results and created more specific codes for the topic of study behaviour. We found that students on entry to university are eager to perform, and by that they mean that they want to understand their courses and pass their exams. The students had different starting goals when entering university. At one extreme end of the range of goals, we found students who were committed to working as hard as they could to obtain P-in-1, at the other extreme we found students who were committed to finding a balance between a rich student experience and passing their courses. The P-in-1 was not viewed as something feasible by most students. Students had mixed feelings about the BSA. Some believed that it was fair for the university to expect the students to make progress and the threshold of 30 credits was seen as reasonable. Some students disagreed, because they believed the BSA just added unnecessary pressure to perform and punished students who were off on a bad start. The communications regarding the BSA were regarded as meaningless, as students already knew how many credits they had obtained or they were regarded as mean. Some students felt that the letter informing them that they were considered to be 'at risk' of discontinuation felt like a vote of no confidence from the university.

The students reported that the course load and the course schedules at DUT were tough on them, the regular deadlines and tests fragmented their time and as a result, students had few opportunities to learn to see the relationships between the topics taught within a subject. The goals and expectations were not always made clear for subjects, exams and projects, which was a source of frustration for the students. Course materials were not always clear or appropriate. Teachers who had a good story to share and did so in a structured, well paced and, preferably, enthusiastic manner were appreciated by most students. Teachers who included feedback on assignments in their classes and who varied their formats, speed and tone were among the students' favourite teachers. Teachers who were rude to students, who spoke monotonously, did not vary and/or repeated themselves a lot, were generally no appreciated and many students decided to skip such lectures and study by themselves. Teachers who supervised projects were appreciated if they were able to clarify what was expected of the students and give constructive feedback in a non-intimidating way. Students observed that not all supervisors were able or ready or willing to answer questions. As in Study 1, students often did not agree as to which teacher or supervisor was good. A teacher who was one student's favourite, could be disliked by another student. This mainly seemed to pertain to a student's personal preferences and a student's attitude: some students were more willing to forgive teachers' their idiosyncrasies or omissions and recognised that they, as students, were also far from perfect, others expected their high standards of teaching every time. Assessment formed a major focal point in the interviews. Students spent a lot of time talking about exams, whether or not they or their peers had passed the exams and they seemed to be genuinely concerned for students who had failed important subjects or subjects that were deemed to be very hard, two factors which often coincided. Students reported that expectations regarding the exam were not always clear. Students did not appreciate exams that were not representative of the subject matter they had studied or for the level at which they were taught. In some cases students could take part exams that either replaced the exam or that counted as a certain percentage of their final grade for a subject. This helped students to stay on top of their work, although these part exams would often be given a higher priority than other assignments by the students and as a result, students tended to lag behind on courses that did not provide such incentives to keep up.

The topics of study behaviour and motivation were given special attention in Study 2, because in Study 1 many students attributed their success to working hard. This observation was consolidated by the results of Study 2: students participating Study 2 also attributed the main share of their academic success to working hard. We wanted to determine what kinds of behaviours students develop to be successful. Success started with the motivation to continue when the going got tough. Many students truly enjoyed the topics they were required to cover, especially when they saw the connections between the subjects and individual topics. Success often led to more success for a student. Success could mean understanding something that a student was genuinely interested in, often after the student had put in the necessary effort to obtain hat success. Success could also mean passing some or all exams, or getting good grades for assignments that a student believed they had really worked hard for. Other important behaviours included spending time on study tasks and putting in the required effort. One way students organised this, was through planning their workload and by keeping with a subject. These behaviours were often interconnected: a student would go to the lectures and keep up with the subject by doing the homework and submitting assignments, but could only achieve this if she or he planned her or his work and non-academic activities around her or his class schedule and around the designated hours for independent study. There were some variations to this scheme: some students attended lectures and keep up enough to be able to catch up in the final weeks before the exams took place. Other students did not plan, and continued this behaviour until they failed exams and then realized they needed to sort out their priorities and probably have some sort of planned study course if they did not wish to fail further. As in Study 1, the students did not bring up 'aptitude' as a topic. Isaac mentioned it in his statement on the randomness of who did well in IDE and who did not, in seeming disregard of the UPE grades for maths students had obtained. At AP a similar topic came up several times: a student who was considered to be the most talented in a mentor group received low grades for maths, just like the rest of the group. The students concluded that aptitude only played a minor role in being successful.

Most of the above mentioned topics have also been covered in the literature review in chapter 3. Issues of course load and course organisation have been studied extensively by many researchers to have a profound effect on learning outcomes: Jansen and Bruinsma (2005), Van der Hulst and Jansen (2002) and Van den Berg and Hofman (2005) studied the effects of curriculum organisation and more specifically, the effects of the spread of subjects and exams over the year. They found that when many smaller subjects in terms of credits were scheduled in parallel, the success rate for the exams went down. Van der Drift and Vos (1987) found in their study that was done in Leiden University that students spent approximately 32 hours a week on their studies and that per hour of scheduled teaching activity students tended to spend two hours of independent study. This proportion changed negatively once the number of taught hours exceeded 12 hours per week. This would imply that the students in DUT spend little time on independent study because their schedules are overloaded and they are expected to spend a lot of time attending lectures each week. Felder (1995), Felder, Felder and Dietz (1998) and Braxton, Milem and Sullivan (2000) found that courses that were taught in an active or cooperative way yielded better student results than traditionally taught students. Vogt (2008) found that perceived distance to faculty impacted student retention. There is a lot of support from the literature for the perceptions from the students regarding the educational environment and that also hold for the students ideas on the importance of the social environment, which has been the subject of a lot of research as well. Hsiung (2010) found evidence that in engineering the project groups play an important role in student success and Oseguera and Rhee (2009) found that the student's aggregated report of stopout, dropout, or transfer intentions independently determined whether a student would persist or not.

Thomas (2000), Wilcox, Winn and Fyvie-Gauld (2005), Eggens, Van der Werf and Bosker (2007) found evidence that a student's social network had a small but important effect on student success.

The importance of student disposition such as motivation, commitment and confidence, as perceived by the students in this study, has also been studied extensively. Bruinsma and Jansen (2007) and Tynjälä, Salminen, Sutela, Nuutinen and Pitkänen (2005) studied the effects of study orientations, such as deep or surface learning and found that students with a deep learning approach tended to be more successful than students with surface orientations. Georg (2009) found that the most important predictor of non-persistence was weak commitment to their course in general or to the specific field of study. Burtner (2005) found that self-reported confidence in college-level maths ability and the belief that an engineering career enhances career security and respectable salary were significant predictors of short-term and long-term persistence in engineering education. Lackey, Lackey, Grady and Davis (2003) found that engagement, attitude and willingness to persevere were important predictors of academic success in the first year of engineering. The importance of effective study behaviours and time on task has also been studied before. Carroll (1963) suggested the importance of time on task and postulated that not all students will need the same amount of time to finish an assignment successfully, as a result of differences in aptitude and in effective study strategies. Bruinsma and Jansen (2007) studied the effects of procrastination and found a negative relationship between this behaviour and learning outcomes. Van den Berg and Hofman (2005) studied the effects of time spent on learning and found a positive effect, except for students from DUT who spent more time on studying than students from other universities but were less successful in terms of the number of credits obtained.

Most of the observations made by the non-persisters regarding their decision to leave DUT can also be found in the literature. None of the students quit their course for a single reason: in all cases there was a build-up of different factors that pertained to elements in the teaching and the learning environment, the curriculum and its organisation, the social environment, their confidence and emotional states, as has been observed by, for instance, Tinto (1987) and Seymour and Hewitt (1997). All of the students were able and hard-working: they all passed a substantial number of courses in the time they were enrolled in DUT. The DUT non-persisters' reasons for leaving were again similar to those reported by Seymour and Hewitt (1997), Baillie and Fitzgerald (2000) and Warps et al. (2010). In this particular case, three students admitted that they were not well enough informed. To some extent this was through their own fault when they made their subject choices and decided to study at DUT. This can be viewed as a shared failing of responsibility on behalf of the students and the university.

The second research question of Study 2 was designed to determine how the variables that affect student success are related. From the interviews we conducted it was obvious that the students attributed their success in a large part to 'working hard'. That is to spend the necessary time on a subject and using a study strategy that is conducive to student success in a specific learning situation. A driver for putting in all this effort was the intention to understand subject matter and the pass courses, or at least the BSA threshold, and a commitment to remain motivated. This observation was backed up by the student built models for success: interest in a subject and planning their workload also contributed to a student's success.

A student's study behaviour was also partly shaped by how a course was organised: did the course allow for an approach to or strategy for studying that was appealing to a student, were the expectations regarding the deliverables and learning goals of the course clearly stated and were the materials used for the course suitable, e.g. did the course books contain answers with an explanation instead of just the outcome of the exercises? This observation on the importance of good teaching materials was supported by the outcomes of the Study 2 student models.

From the interview outcomes we deduced that student behaviour is also influenced by how students perceive a teacher. If students liked the teacher, they tended to be more willing to put in effort. If the teacher was perceived to be very good at explaining their subject matter and entertaining, preferably both, many students would enjoy attending the teacher's lectures as one of the ways they would study the teacher's subject. If the teacher was perceived to be poor some students might still go to the lecture, but for most students it meant they had to master the subject matter by themselves through independent study. This observation was also consolidated in the outcomes of the students' Study 2 models: the motivation and quality of teachers had a direct and indirect impact on student success in the models.

Positive experiences in the teaching and learning environment tend to strengthen a student's motivation and commitment to a subject or course, however, what constitutes a positive experience to one student is different for another. The most positive experience the students reported in the Study 2 student models, was a balanced curriculum, with plenty of time to recharge motivation and plenty of time to do the work.

The social environment at DUT came up in every Study 2 interview and could be described as one of the major support systems for a student maintaining effective study behaviour. A benefit of going to lectures was meeting peers and friends. Fun and committed peers in project groups helped students to persevere in a course. Meeting flatmates and friends at the associations just outside the circle of a student's course, helped students to learn to navigate the murky waters of university and it helped them to stay sane. From the Study

2 student models we found that the social environment was important to many students, and it formed part of 8 out of 10 models. In most models the social environment was seen as having an indirect effect on success, which is in line with the observation that the social environment is a support system, and does not have a direct influence on success.

A topic that was brought up in the modelling workshops, but that did not emerge from the interviews as such, were university facilities. Facilities seem to matter to the students, but to a lesser extent than the other variables included in the models. The student mentors were mentioned often by students as a source of information and support in getting started early in the year. A good atmosphere in the faculty was appreciated and meant that the students enjoyed going to the faculty and campus.

6.6.2 | Discussion

A limitation of qualitative research is that only a relatively small number of participants can be included in such a study. In this study we recruited a relatively large number of participants, but this created some new problems and therefore limitations. As a result of the way we set up the group interviews it was often not possible to retrace all the statements to individual students, which limited the inferences we could make based on the data, because we could not be sure which statements were made by which student. This also meant we could not connect the notes on the stimulus objects to the individual respondents. Not all of the student participants participated in all of the interviews for Study 2 and as a result, we were forced to analyse the interviews at the level of the groups. This limited the depth of the analysis.

One of the aims of the study was to verify Study 1 findings using a representative sample of the DUT first year student population. This did not work out completely: we did not manage to recruit students from mechanical, maritime and aerospace engineering. In addition, we only managed to interview one student from SEPAM and one student from IDE, and this student left university. We believe that the outcomes of the study have enough density and quality to answer the research questions, but we cannot be sure we achieved our aim of sampling a representative DUT first year population. In chapter 2 we discussed the differences in subcultures between fields of engineering. Although this topic did not emerge from the analysis, the researcher made many observations of differences between the faculties. Students talked about other courses in various ways, students of engineering tended to be derogatory towards architecture and to IDE to a lesser extent. The students in architecture would sometimes note that the students from other faculties acted as if architecture had little to do with higher education. Most students, however, were ill informed about courses other than the one in which they were enrolled. In the workshops a student from AP was surprised to learn that one could actually study mining engineering in DUT. In the conversations about which variables to include in the models and how they were related, it turned out that students only focussed on their own course and had little notion about what was going on in other faculties. They were often surprised that in other faculties things were organised and experienced differently. To us this served as extra support for the idea that it is meaningful to test our model for student success for subpopulations of DUT based on their disciplines.

One of the specific foci of this study was to include more non-persisters. As in Study 1, we relied on the students to inform us if they decided to withdraw from university. We decided to use this strategy out of respect for the privacy of the students. We had promised them that we would not check their progress or status with the administration, to create a sense of safety and privacy during the interviews. In addition to students informing us of their withdrawal, we asked group members if they knew anybody who had withdrawn. Most students did not have a lot of information on who was still studying and who was not. When emails bounced or were not replied to, we attempted to contact the student at his or her private email address. We did not get any answer and in some cases the email bounced as well. Trying to establish a connection through the mobile phone also did not yield any results. We tried to recruit more non-persisters through the DUT Career Centre, but that did not work. In the end we managed to talk to four students who withdrew while they were part of this study. The major reason for wanting to involve more non-persisters was to develop models for student persistence and for student non-persistence. Success and lack thereof are not a mirror image (Tinto, 2012). We no longer perceive building a model for non-persisters to be an option, as we cannot base such a model on the responses of 6 non-persisters. This implies Study 3 presented in the next chapter in which a attempt is made to answer research questions 2 and 3, presented in chapter 4, can only be a model for student success, and not for student non-persistence.

In Study 2 only one researcher reviewed the codes and coded the transcripts. In spite of having taken the utmost care when using the coding process, this could be a source of researcher bias in the analysis.

Many of the predicates of student success discussed in the previous sub section are also found in the body of knowledge discussed in chapter 3, in which the literature review was presented. Most of the outcomes of this study are not completely new, a fact we interpret as support for the validity of our studies' outcomes. The topics included in the previous section should form part of a preliminary model for success, but there is also convincing support for the inclusion of variables in the model that were discussed in the literature review, but which did not surface in this study.

Chapter 7

Study 3: A model for first year engineering student success

7.1 | Introduction

In this chapter the outcomes of the literature review and those of the Studies 1 and 2 are combined into a model for first year student success. We suggest a preliminary model for first year student success based on the outcomes of the research presented so far, and we test this model to explore which of the relations are supported within the wider population.

We answer two research questions in this chapter. The first is: which relations between independent and dependent variables in the model can be established for the population of first year DUT students? To answer this research question the preliminary model based on the rich data presented so far, needed to be reduced, as it was unlikely that there would be support for every item that surfaced in the previous studies. In the previous studies we observed that there were clear differences between faculties in how the courses are organised and subtle differences between cultures in the faculties. Our second research question is: what differences, if any, exist between students from the engineering, science, and design courses in the reduced model?

7.2 | A situated model for success

7.2.1 | The preliminary model

To select the variables that should be included in the DUT situated model for first year student success, we analysed a number of key publications in the field on the level of dependent and independent variables. We made an inventory of which variables were included in which studies and the effects these variables had had in these studies. We complemented the outcomes of this exercise with the outcomes of Studies 1 and 2. We ended up with a long list of variables. Based on frequency with which variables had had effects, the effects sizes and the relevance of the research contexts of these studies for DUT, we shortlisted the variables that are listed and described in the first two columns of the table given in Appendix 3. These variables were assigned to the following clusters of variables.

1. Measures of success, such as progress.
2. Student behaviour, including time on task and study behaviour.
3. Student dispositions, including confidence, motivation, intentions and commitment
4. Perceived quality of the education environment, including teachers, assessment, organisation and facilities.
5. Attributes of the education environment, such as number of exams and scheduled teaching and learning activities.
6. Students' social environment.
7. Student attributes.

Next, we organised the clusters based on the narratives of the students found in Studies 1 and 2 and on relationships between these clusters found by previous researchers. The resulting model is shown in Figure 7.1.

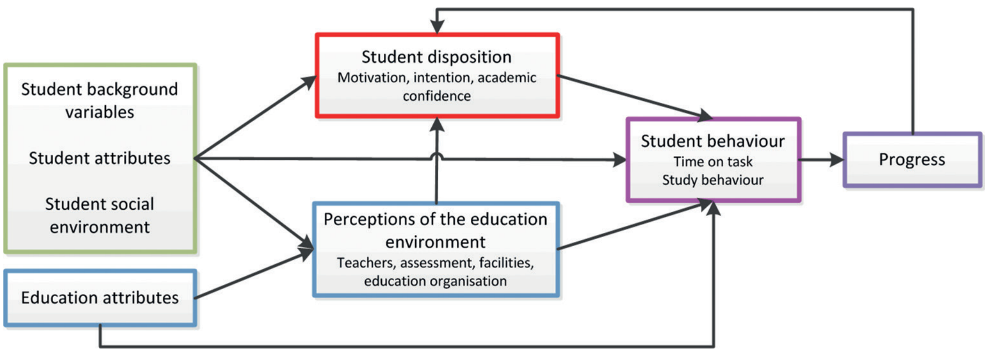

Figure 7.1 | Preliminary model for first year engineering student success in DUT.

The body of the model is made up by the interaction between student behaviour, dispositions and perceptions of the education environment. Behaviour was taken as the mediating variable between progress and the other variables, because perceptions and motivations cannot directly and logically lead to good results on a test. Motivation and aptitude are essential, for example, for a student to study mechanics and to see it through until she or he understands how external loading affects shear and normal stresses in a beam and what the implications are for beam deformation and behaviour when it is performing its task within a structure. Without putting in time and effort, only a very small proportion of students will be able to pass exams. For a model to have value in practice, it needs to represent real processes the way they are. Therefore a mediating variable is needed between progress and the other clusters of variables. Behaviour in its turn is influenced by student disposition variables, the perceived quality of the educational environment and student features, such as aptitude. The student disposition variables pertain to those student attributes that are susceptible to change over time, such as motivation, intention and confidence. The students in Studies 1 and 2 observed that without motivation, intention and confidence effective study behaviours cannot be kept up, but they also observed that perceptions of teachers and experiences with course organisation, the facilities provided and how a course is assessed influence how students study. Progress feeds back into motivation, based on the observation that success tends to lead to more success, as students feel empowered and motivated to keep up their efforts.

The remaining clusters of variables are student attributes, the social environment and education attributes. Student attributes and social environment were both taken as student background variables and feed into dispositions and perceptions of the education environment, and also directly into behaviour. As students with high aptitude will probably need less time to master a skill than students with less aptitude and such a student will probably have different study behaviours. The social environment also influences behaviour, as peers and flatmates can influence behaviour to some extent. We assume that student attributes and social environment also have some influence on how student perceive their education environment and on their intentions, motivations and confidence. The education attributes are the conditions under which the education environment is designed. The number of lecture hours in some way, affects how teachers organise their classes and course assessments. It may be possible that education features also directly influence student behaviour. The model shown in Figure 7.1 contains two systems: the student related system on top and the education related system at the bottom of the model.

7.2.2 | Operationalisation of the preliminary model

The next research step was to operationalize the clusters of variables. Again, we used the sources given in the inventory in Appendix 3 and the outcomes of Studies 1 and 2 to come to an operationalization that we deemed appropriate for the research context of DUT. The definitions of these variables, shown in the second column of the table are included in Appendix 3, and the operationalizations of the variables are shown in the third column of the same table. The model in which the operationalisations of the variable clusters are shown is presented in Figure 7.2.

The education environment cluster consists of elements of the teaching and learning environment as perceived by the students. The elements in this cluster can be operationalized in different ways. For instance pedagogical competence of teachers could be operationalized by counting the number of qualified teachers in a faculty, however, after all the interviews we did we felt that the students were able to assess their environment in a fair way. All the variables included in this cluster reflect visible elements of the education environment. Thus, if the data generated from the students' perceptions flag a specific element as problematic, this gives officers plenty of information to start looking for where such problems might lie and what they are.

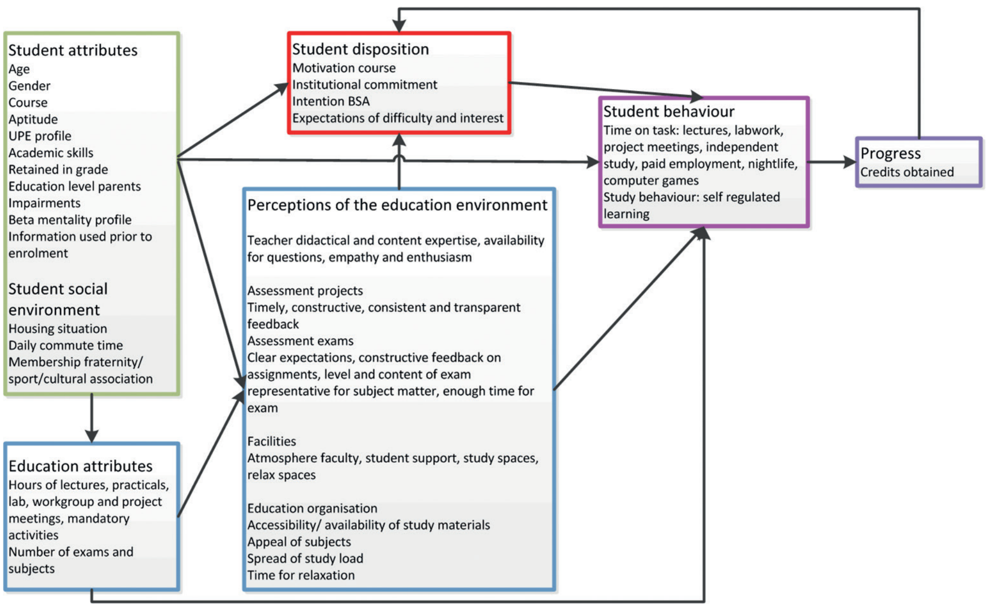

Figure 7.2 | Preliminary model with operationalizations of the variable clusters

The teachers' didactical and content expertise refers to the ability of teachers to explain the materials and the extent that students perceive the teachers to be available to their needs. Assessment pertains to the perceived quality of project assessments and exams.

University facilities includes having a good atmosphere in the faculty so it is appealing for students to be there, and it includes availability of places to study and to relax, and the student support that is available. Education organisation is operationalized to contain the accessibility and availability of materials, the appeal of courses to students, the students' perceptions of the spread of a course load and whether there is enough time to relax.

We chose to use the framework of self regulated learning for the operationalization of study behaviour (Bandura, 1997; Zimmerman & Kitsantas, 2007; Zimmerman, 2000), because this is a well-supported framework and it has previously been used successfully in tertiary engineering education (Litzinger, Wise, & Lee, 2005; Schmitz & Wiese, 2006; J. Stolk, Martello, Somerville, & Geddes, 2010). Self Regulated Learning (SRL) theory poses that every learning process consists of three distinct phases that need to be followed through to produce desired learning outcomes. This process is cyclical and can be repeated over and over again. The three phases of SRL are the pre-action phase, the action phase and the post action phase. In the preliminary model student behaviour also includes time students spend on tasks, including independent study, lectures and course related time on task, employment, partying and computer games.

7.3 | Methods for quantitative analysis

The model shown in Figures 7.1 and 7.2 is a path model, as it includes a series of dependence relationships. We tested the model using structural equation modelling. This technique and the data collection necessary to use this technique are described below.

7.3.1 | Structural equation modelling

Structural equations modelling (SEM) is linear statistical technique that is essentially a combination of regression and exploratory factor analysis (EFA) that is used to estimate the relations between constructs and measured variables and relations between constructs simultaneously (Ullman, 2007). This allows concurrent estimation of indirect and direct effects in a model. A structural equation model consist of measured, or observed, or manifest, variables, and unobserved variables such as latent variables and residual terms, and of arrows between the variables that represent the relationships. Latent variables represent variables that cannot be measured directly, but can be represented or measured using one or more manifest variable(s). All dependent variables, latent or manifest, are accompanied by an error or residual term, as nothing can be predicted perfectly. Then, because the error of the estimations of the relationships is removed, only common variance remains as a value (Ullman, 2007). Any structural equation model starts with a specification of the model, and as such, SEM tests whether or not the model fits the data. Therefore SEM is a confirmatory rather than an exploratory technique: SEM tests to what extent the model fits the data. According to Ullman (2007) SEM can be used for different goals: it might be used to test a model, to test specific hypotheses about a model, to modify an existing model or to test a set of related models.

Structural equation modelling is a complex technique and this increased complexity makes high demands on the data used for the test. Traditional SEM is based on a maximum likelihood estimation, which is sensitive to missing data, it requires data to be normally distributed and continuous and it needs a large number of cases in a dataset to give reliable estimates.

7.3.2 | Data collection

To test the preliminary model, we needed data on student progress, student attributes, students' dispositions, students' perceptions of their education environment and the attributes of the education environment. Some of this data was readily available from DUT's administrative systems: the digital study guides and Osiris. The digital study guides contain information on the education attributes. We collected the information that was needed and verified the information with the faculties' education coordinators. Osiris contains some information on student attributes, such as age, gender, UPE profile and final UPE grades and information on student progress, including grades and number of credits obtained. It does not contain any other information on students, such as information on impairments or parental levels of education. Within the university the faculties' quality control officers evaluate subjects on a regular basis and collect a lot of student perception data. These surveys, however, are done anonymously and cannot be linked to other data sources, which made them unusable for our research because our research was contingent on obtaining complete data records from students. In addition, the faculty subject evaluations do not contain any information on student dispositions and their behaviour. This information could only be gathered by developing and then administering a questionnaire.

7.3.2.1 | Development of a questionnaire

The questionnaire was based on the selection of variables made to operationalize the model. Most of the studies referred to in Appendix 3 included the questionnaires that were used. We used questions from these questionnaires as examples or sometimes as a template. Some variables were selected based on the interviews with students: for these variables we formulated the questions ourselves instead of basing them on examples from the literature. Items for which there could be specific DUT answers, such as the question on what PR activities students may have participated in, were checked with well-informed officials from DUT.

Two questionnaires were drawn up: one for the 2009 student cohort and one for students from the 2010 cohort. These questionnaires were administered simultaneously: in October

2010. By this time, the students from the 2009 cohort were in their second year, while the students from the 2010 cohort had just finished their first round of exams in their first year in university. The 2009 cohort only consisted of the students who had passed the BSA threshold the previous year and a number of students who was allowed to continue due to special circumstances. The questionnaires were identical, except for two extra questions in the questionnaire for the 2009 cohort. The 2009 questionnaire contained 45 questions; while the 2010 cohort questionnaire contained 43 questions. Most of these questions were dichotomous items where the respondents had to answer whether or not attributes or conditions applied to them. In other questions respondents were asked to rate conditions or behaviour on 5-point Likert scales. We opted for the 5-point Likert scale because this is the scale used for all the course evaluations that are done by the faculties' quality control officers and the students are familiar with this scale. The questions on the education environment also had an answer option to indicate the questions were not applicable. Some questions contained space to clarify answers. This opportunity was only used a few times, however. In some questions students were asked to fill in how much time they spend on something, such as a one way commute, independent study, etcetera. Only the question asking for the students' DUT student number was made mandatory, as this was essential information for linking data files. It was estimated that it would take approximately 15 minutes to fill out the entire questionnaire.

The questionnaires were reviewed by two research professors and by a student several times, before they were put out as an online application. The application that was selected for this purpose was Surveymonkey.com. This application allowed a URL to be made that was easy to recognise and publish. It did not allow for individualised URLs that could be linked to a student's email address. We will go into this further in the next subsection. The online questionnaire was also tested and adjusted several times by the principal investigator, the research professors and by the student.

It was essential for students to give their unique student number so their data could be linked with other data sources. This created some ethical concerns that were addressed by explaining the reasons to ask for this data and by explaining how the data coupling would take place, and how the data would be used and stored. This information was included in the invitation email sent to the students and on the first page of the online questionnaire. The questionnaire for 2010 cohort is included in Appendix 4, together with the two extra questions that were included in the 2009 cohort questionnaire.

7.3.2.2 | Data collection and response

Emails with the URL to the questionnaire were sent out to all first year and second year students enrolled at DUT the time of the survey. After two and four weeks reminders were sent out, and to increase the response rate, the researcher gave short presentations at large first year lectures at ME, EE, AR and AE. At CE the mentor coordinator asked the student mentors to bring up the questionnaire and ask for student participation. In addition, we asked the TU Delft campus newspaper and a number of study associations to publish the URLs in their newsletters or on their websites.

The questionnaire was aimed at Dutch speaking students only. At the time, there was only one bachelor course, Aerospace Engineering, where the first year was offered in English in addition to Dutch. We particularly wanted to recruit Dutch students as this would mean the response group would be more homogeneous in terms of prior education.

Table 7.1 | Attributes of first year DUT students from cohorts 2009 and 2010 and those of the response groups participating in the study. In both cases the response groups obtained a significantly higher average number of credits than the first and second year student population as a whole.

	Total first year DUT 2009	Response cohort 2009	Total first year DUT 2010	Response cohort 2010
	2667	568 / 21%	2653	584 / 22%
Gender: % male/female	78 / 22	66 / 30	76 / 24	72 /28
Faculties				
3ME	15.5%	16.1%	17.2%	18%
Architecture	20.3%	19.5%	17.5%	19.3%
CE and Geosciences	13.3%	12%	11.6%	18.2%
EEMCS	10.3%	10.2%	8.5%	10%
IDE	11.7%	11.2%	14.7%	7.9%
AE	13.5%	13.3%	16.0%	17%
SEPAM	5.8%	7.3%	5.2%	4%
AP	9.4%	4.5 %	9.9%	5.5%
N EC obtained in first year	Av. 37.6	Av. 47.1	Av. 40.6	Av. 45.1
N EC obtained in first term	Av. 6.5	Av. 3.6	Av. 7.3	Av. 7.8

NB: In both cases the response groups obtained a significantly higher average number of credits than the first and second year student population as a whole.

7.4.3 | Data cleaning, preparing the data set

The raw 2009 datafile from Surveymonkey contained 607 cases, and the 2010 datafile contained 700 cases. This included a small number of students who had started the survey at some point and finished it at a later time. In these cases the last entries were included in the file. Cases missing more than 50 per cent of the answers were deleted.

Once obtained the data files were merged with data obtained from Osiris based on a student's unique identification number. There were a number of cases for which the unique student ID did not exist in the database. These cases were kept in the database, but contain many missing data points. In two of the cases the age of the cases were outliers and these cases were removed from the data file. Our final dataset consisted of 568 cases from cohort 2009 and with 584 cases from cohort 2010.

We had included a question in which students were asked to give estimates of how much time they had spent the previous week on a number of activities, such as independent study and leisure. When we were exploring the data as part of the data cleaning exercise, we found that the range of values given by the students were unrealistic and sometimes impossible. We decided to remove these values and leave time on task out of the data analysis.

When we look at the representativeness of the response, it is clear that the response is representative of the wider population in terms of gender and course enrolment, but not in terms of the number of credits obtained at the end of the first year. The respondents obtained significantly more credits than the wider population. It is not clear how this occurred, but there is a parallel to the observation that it has been hard to find students who left university who were willing to participate in an interview. It is well possible that less- and non-successful students do not answer to these requests to participate in research and data collection on this topic. These data support the fact that we are designing a model for student success, and not a model for non-success.

The first exploration of the data was aimed at reducing the model. This exploration was done using basic statistical techniques such as correlation analysis, tests for significant differences between groups and exploratory factor analysis (EFA). For the model assessment, using confirmatory factor analysis techniques, we were more stringent as SEM is sensitive to missing data. For this purpose we removed all cases where data was missing for the questions on study behaviour. This gave 532 cases for cohort 2010 for the CFA portion of this study and 493 cases for cohort 2009.

Negatively worded items from the questionnaire were recoded; so all the scales were in the same format. A number of questions were posed in a dichotomous format. For some variables the answers were taken together as parcelled variables on a ratio scale.

7.4 | Results of preliminary analyses for model reduction

The first analyses were done using SPSS to explore correlations and factors in the data. This was done to reduce the number of variables that were eligible for inclusion in the structural equations model.

7.4.1 | Initial results: model reduction

We started with exploring the preliminary model from the output variable to the throughput variables for the model reduction. Then the relations between the throughput variables were studied, followed by an exploration of the student background variables. The hypotheses that were tested and the statistical outcomes for cohort 2010 are given in Appendix 5 and for cohort 2009 in Appendix 6. Most of the data was measured at an ordinal level, this meant we analysed the data using mostly non-parametric tests (Field, 2009), also see Appendices 5 and 6 for details of all hypotheses tested and of the statistical tests used for this testing. In this subsection we will briefly review the processes used to test our data and the outcomes. The names used in the section refer to the questions in the survey. Note: the names of the variables are included in the third column of Table A3.1 in Appendix 3.

Table 7.2 | Strengths of correlations, based on Cohen, Manion and Morisson (2011).

Correlation value	p-value	Relationship strength
.100 to .149	.01 or smaller	Weak
.150 to .249	.05 or smaller	Moderate
.250 to 3.99	.05 or smaller	Reasonable
.400 or higher	.05 or smaller	Strong

When we use non-parametric tests for significance we report the effect sizes of the effects we found. Cohen, Manion and Morrison (2011) set some standard cut off values for what can be considered to be weak (values from 0.1 to 0.25), modest (values from 0.3 to 0.45) and moderate effects (0.5 to 0.75). Scores above these scores have strong to very strong effects. Cohen, Manion and Morrison argue that these are not a golden standard and that it depends on the field of research what cut off scores indicate weak, modest or larger effects. The field of student success in higher education is complex and therefore we will consider the following scores: 0.1 to 0.25 for weak and moderate effects, 0.25 to 0.4 for reasonable effects and above 0.4 for strong effects.

7.4.1.1 | Initial results of cohort 2010

The first hypothesis checked was whether the three separate phases of self-regulated learning (SRL), see also section 7.2.2, could be established based on the data. This was not the case as is presented in Table A5.1.1[16]. The factor analysis presented in A5.1.4 showed relations between variables that seemed to pertain to similar concepts, such as study discipline, dealing with study load, deep learning and focus, but this did not bear any resemblance to concepts from SRL. The above factors explained 52.8 per cent of the total variance in behaviour. The correlations between the student behaviour variables and the total number of credits after the first year (EC Total) were weak to moderate, as shown in A5.1.1. Three student behaviour variables did not show any correlation with 'EC Total', 15 behaviour variables showed weak to moderate correlations, 'Behind' and 'Mark' showed correlations of nearly .40. The p-value of the correlations was very low, indicating that the probability that the outcomes were based on chance was small.

The construct of student disposition was taken to be the whole of course and institutional motivation, expectations regarding the difficulty and interest students had in the course

[16] The complete set of hypotheses and outcomes of the statistical tests is given in Appendix 5.

and intentions for success. Motivation regarding course and institution was measured using a number of dichotomous items regarding the importance of elements of studying at DUT and of the courses, prior, during and after the courses. These items were added, or parcelled, to obtain continuous items. Student expectations and intentions were measured using direct questions on how the students experienced the level of difficulty of their course and the amount of interest they had in it. Correlations between motivation and student behaviour were very low and the p-values were relatively high. The only correlation worth mentioning is presented in A5.5.1: Spearman rho=.145 with a p-value of .001 between 'Cours aft', which is a measure of how students expect to perceive their courses after graduation and 'Deepl2', which is a measure of whether students study for deep understanding or not. The correlations between expectations and intentions and student behaviour are more interesting: there are many weak, moderate and reasonable correlations with very low p-values, as presented in A5.5.2. It seems that 'Importance of P-in-1' has the strongest relation with student behaviour, followed by 'Expectancy of obtaining a positive BSA'. Regarding the perceptions of the educational environment, there are only a few correlations between teacher related variables and student behaviour and those are weak to moderate in strength, as can be found in A5.6.1. There are two factors to be discerned within the teacher variables, see A5.3.1. The first factor is didactical and personal skills, which shows more correlations than the second factor that pertains to a teacher's availability, as presented in A5.6.5. For perceptions of project and course assessment there are few weak correlations, but there are more correlations between the perceptions of exams and student behaviour than between students' perceptions of project assessment and student behaviour. Within the cluster of facilities, shown in Table A5.6.3, only atmosphere shows weak to moderate correlations with 11 out of 20 student behaviour variables. Education organisation variables show weak to moderate correlations, with "OO Material' also showing some apparent correlations and 'OO Late' and 'OO Book' not showing any correlations, as shown in Table A5.6.4. In Table A5.9.1 correlations between student dispositions and perceptions of the Educational Environment are presented: again there are mostly weak to moderate correlations, especially between 'Expectancy of difficulty' and 'Expectancy of interest' and the variables of education environment perceptions. Again the p-values are low.

We tested for relations between student behaviour and student attributes. This was done using tests for significant differences in scores on student behaviour variables and student background variables. We tested for differences between female and male students; the outcomes are presented in A5.7.14. We found significant differences in 8 student behaviour variables, where in most cases the female students scored higher than the male students. In Table A5.12.4 we present differences between the education environment for male and female students: women scored lower on perceptions of teachers, but there were no apparent patterns in the remainder of the data, and the effect sizes were small. Parental education level did not influence student behaviour variables, as can be found in A5.7.15. We also tested for differences in student behaviour and perceptions of the education environment between students who were members of all kinds of associations, including fraternities, and those students who were not affiliated with any associations, and between students who lived independently or with their parents. As presented in Table A5.12.2, we found some differences, but there were no clear patterns and the effect sizes were very small, usually they did not exceed r=.20. There were positive and significant relations between aptitude, operationalized as UPE grades for maths and physics, and expectancy of a positive BSA and the importance of obtaining the P-in-1, as shown in A5.10.3. Correlations between the disposition variables were moderate to strong and tended to have small p-values, except for the motivation variables, which showed a few correlations within the motivation cluster, but did not correlate outside that cluster with the other disposition variables.

All in all there were enough correlations of a low p-value to conclude that there are relations between the clusters of variables we identified for the preliminary model. The relations are mostly between .10 and .40, which is not very strong. We also ran factor analyses on the education environment variables presented in A5.3.1 and found only three Crohnbach's Alpha coefficients that were commonly found to be of weak or of acceptable strength. The other Alpha coefficients were strong.

7.4.1.2 | Initial results of cohort 2009

The tables containing the hypotheses used for cohort 2009 and the outcomes of the statistical tests are given in full in Appendix 6. There were fewer student behaviour variables that correlated with 'EC Total' than found for the 2010 cohort, but the ones that did correlate, correlated in both data sets, as shown in A6.1.1. The factor analysis on student behaviour variables that correlated with 'EC Total' explained 60.4 per cent of the variance, Table A6.1.4, but different factors were highlighted here than those for the same analysis of cohort 2010. Again, the concepts of self regulated learning did not surface in this analysis. The student behaviour variables correlated weakly with only a small number of the education environment perception variables. Relations were found between student behaviour variables and some of the teacher variables as presented in A6.6.1: if the teachers had plenty of content knowledge, and if the teachers were empathic and available to the students. Within the assessment variables shown in A6.6.2, an effect was found only for clarity of expectations for a test. Within the facility variables the only effect that was found was for faculty atmosphere as experienced by students, Table A6.6.3. For educational organisation there were effects for how accessible materials were and time for relaxation. All these correlations were positive, as presented in A6.6.4. A factor analysis was performed on the perception variables and the otucomes are included in A6.3.1: they clustered in the same way as found for the 2010 cohort, with the exception of the education organisation variables. This is not surprising, as the questionnaire for 2009 contained two extra questions on that topic. We added up the outcomes on the separate variables to create new perception factor scales and looked at the correlations between these new variables and student behaviour, but there were few correlations and they were weak, as can be found in A6.6.5. In Table A6.8.1 the correlations between education attributes and student behaviour variables are shown, but there are only a few of them and they are weak to moderate correlations of strength. The attributes only had effects in the first term, and within the grand total scores of attributes only the total number of participatory learning activities had some effects. These results do not differ from those of the 2010 cohort.

The motivation variables did not show any notable relations with the student behaviour variables, Table A6.5.1, the expectations and commitments did, as is shown in A6.5.2: for the 2009 cohort an extra question was added in this section to determine whether or not the students had obtained their P-diploma at the time of filling out the survey. This variable showed moderate and strong correlations with 9 of the student behaviour variables.

Student attributes such as gender, parental level of education, science orientation, and course did not have any notable effects on the student behaviour variables, nor did the social environment variables such as membership of associations and housing situation, as shown in the tables in section A6.7. Gender did have effects on a student's perception of the education environment, including most of the OO variables, which was not the case for the 2010 cohort, however, the effect sizes were small: between .10 and .20. These outcomes can be found in Table A6.12.4.

Tests of the students' perceptions of the education environment showed a few relations with disposition variables, the expectations of how interesting students found their courses especially showed moderate to reasonable correlations with their perceptions of teachers and assessment, and with their perception of faculty atmosphere and of appeal of the courses offered, shown in section A6.9.

7.4.2 | Reflections on the initial results

What stands out from these analyses is that we found a small number of correlations, and those that were found tended to be moderate with small p-values. This meant that although the effects were small, they were persistent in the sense that the probability that these relations were based on chance was small. Let us review the clusters and the relations between the clusters of variables. The clusters of education attributes and student attributes, including the social environment, were not analysed for internal consistency, as they were considered to be exogenous variables in the model.

The student behaviour cluster did not bring out the concepts of the SRL framework that were used to frame and phrase the questions, see Tables A5.1.1 and A6.1.1. Some of the variables dropped out in the sense that they did not correlate with the other student behaviour variables, nor with the output variable of the model. These variables were the same in both cohorts and which allowed them to be dropped for the next step of the research. The remaining variables were analysed using factor analysis, as shown in Tables A5.1.4 and A6.1.4. The factors that emerged explain between 50 and 60 per cent of variance found in the behaviour. The variables clustered somewhat differently in the cohorts, but overall similar factors emerged.

The variables pertaining to education environment were analysed using factor analysis, as shown in Tables A5.3.1 and A6.3.1. In cohorts 2010 and 2009 the teacher, assessment and facility variables clustered on the same variables. The emerging factors for teachers and facilities explained a similar amount of variance, the assessment factors in 2010 explained 12 per cent more than the same factor in the 2009 data set. The 2009 dataset for education organisation contained two extra questions extra and in this dataset two factors emerged from this sub cluster of variables. We calculated the Crohnbach's Alphas for these scales and found that some satisfied the criterion for reliable scales which is commonly set at the cut off score of .70 for reasonably reliable scales (Cohen et al., 2011; Cortina, 1993).

In both cohorts the disposition variables showed a similar outcome: there were correlations within the motivation cluster, but these variables did not show any correlations outside this cluster, as can be found in Tables A5.5.1, A5.9.2, A5.10.3, A6.5.1, A6.9.2, and A6.10.2. The other disposition variables: expectations, intentions and confidence showed moderate to reasonable correlations, as shown in Tables A5.5.2, A5.9.1, A5.10.3, A6.5.2, A6.9.1 and A6.10.2. The motivation variables were dropped.

When we considered the relations between the clusters of variables, we observed the following. There were a number of student behaviour variables that correlated moderately to strongly with the number of credits obtained, but these correlations ranged between .10 and .35, as shown in Tables A5.1.1 and A6.1.1. Again, the p-values were small. That meant that there must be other variables that influenced the number of credits that students obtain, but that these variables were not included in our model. All the other clusters fed into the student behaviour cluster.

The relation between the student behaviour cluster and the perceptions of the education environment show mixed outcomes. Some of the variables from the education environment cluster showed moderate to strong correlation with student behaviour variables, while other variables did not show any correlation, for instance the FC variable 'teacher mentor', and the education organisation variables 'OO Late' and 'OO Book', see the tables in section A5.6. When we looked at the correlations of student behaviour variables with the scaled education environment variables, presented in A5.6.5, we observed that it was mainly the TC1, teacher didactical competence, TS1, project assessment, and OO, education organisation in general, scales that showed a lot of correlations with the student behaviour variables. This was not surprising, as we would expect this based on the outcomes of the interviews of Studies 1 and 2. In the analysis of Cohort 2009 we saw even fewer correlations between these clusters of variables, although teachers' didactical competence and education organisation continued to stand out, as can be found in section A6.6.

The relations between the student behaviour cluster and the education attributes were negligible. The only observation that could be made for the 2010 cohort was that there was a weak negative relation between the number of exams and student behaviour in the third term, as presented in A5.8.1. For the 2009 cohort there was a different pattern as can be seen from A6.8.1. The number of participatory learning activities showed some moderate correlations in term 1 and 3 and the number of these activities overall. The number of lectures had modest negative effects overall and for term 1. The number of exams also had a modest negative effect in the first term. Again, these effects were weak and moderate correlations, with small p-values.

The relations between disposition and behaviour for the 2009 and 2010 cohorts showed a similar outcome: the importance of P-diploma correlated with a fair number of student behaviour variables with the correlations ranging between .125 and .461 for 2009, Table A6.5.2, and between .113 and .455 for cohort 2010, Table A5.5.2. The other disposition variables showed different patterns among the years. For the 2010 cohort there were relatively many correlations for expectation BSA and some for expectations for difficulty and interest and for the importance for studying in Delft. Cohort 2009 attached little value to the importance of Delft, but much more to the expectations of interest students had in their courses.

We tested the relations between student attributes and social environment, and behaviour. The social environment had negligible effects on behaviour. We tested for the effects of housing situation and memberships and we found some differences, but these differences had a small effect size and there were no patterns that could be distinguished, in either cohort 2009 or cohort 2010, see Tables A5.7.1 to A5.7.13 and A6.7.1 to A6.7.1.13. Parental level of education, science orientation, UPE profile and grade retention did not have any noteworthy effects on behaviour in either cohort, see Tables A5.7.15 to A5.7.18 and A6.7.15 to A6.7.18. Gender did have some effects, and in both cohorts the female students scored higher on the behaviour variables, although the effect sizes were very small, as presented in Tables A5.7.14 and A6.7.14. Aptitude also had some effects in both cohorts, although there were more effects in cohort 2010, see Tables A5.7.13 and A6.7.13.

The course did not have any noteworthy effects on behaviour in either cohort, as can be seen in Tables A7.1.1 and A7.2.1.

We also looked at the relations between disposition and student attributes and disposition and perceptions of the education environment. No differences were found for either cohort for student dispositions between students who were members of associations, between male and female students and students with different science orientations, as can be seen in the tables in sections A5.10 and A6.10.

There were significant differences in perceptions of the education environment for the 2009 cohort. In the area of teachers and education organisation especially female students scored differently: females scored significantly lower on all the teacher and assessment variables and they scored higher on almost all organisation variables, as shown in A6.12.4. For the 2010 cohort we found no differences on perceptions on education organisation, but we found the same lower perceptions of teachers and assessment on behalf of the female students, as shown in A5.12.4. There were no notable differences in perceptions of the education environment between students depending on parental level of education, science orientation or impairments, as presented in A5.12.3. There were differences in scores on perceptions of the education environment between students from different courses. These differences can be found in Tables A7.1.3, A7.1.4, A7.2.3 and A7.2.4. There were some differences in perceptions of the education environment between members and non-members and between students who lived independently or with their parents, but no clear patterns emerged for either the 2009 or the 2010 cohorts, as shown in Tables A5.12.1, A5.12.2, A5.12.3, A6.12.1, A6.12.2 and A6.12.3.

In student cohort 2009 there were some correlations between perceptions of the education environment and dispositions, but no patterns emerged, see section A6.9. Expectations of interest showed most correlations of moderate size, as presented in A6.9.1. In 2010 expectations regarding interest and difficulty correlated with teacher and assessment variables, but apart from these correlations, no clear patterns could be found, see Table A5.9.1. The final relations we tested were between the success measure and student disposition. In both cohorts almost all disposition variables were affected by the number of credits and the correlations were of reasonable size. This is presented in A5.10.8 and in A6.10.8.

Based on the outcomes discussed so far, we were able to conclude that we could leave out a number of variables in the next step of the model reduction process. The social environment variables did not have any notable effects, nor did most of the student attribute variables and the motivation variables. We could also leave out a number of the behaviour variables. The education attributes did not have any notable effects in cohort 2010, however, they had slightly more effect in cohort 2009.

The number of correlations that were found and their effect sizes do not provide strong support for the model, however, as the p-values of the correlations that we did find were low. A summary of the outcomes that can be found in Table 7.3 in the next section 7.5.2. The outcomes are combined with initial structural equation modelling outcomes. To this point we had mainly used statistical tests fit for non-parametric data, however, SEM is intended for use with continuous data. Therefore we checked the skew and kurtosis of the remaining variables and found values that indicated that the data that was left was not normally distributed.

7.5 | Results of Structural Equation Modelling

We discussed in section 7.3.1 how SEM puts strict requirements on data, and that it is sensitive to problems in datasets, i.e. missing data, small sample sizes and non-normally distributed data. The SEM technique is intended for modelling continuous data, but according to Byrne (2010) SEM performs well with ordinal data if it is normally distributed, which was not the case for the data collected for this research. In addition, the datasets were relatively small after the removal of incomplete cases. These considerations made use of traditional SEM an unattractive path to take: in SEM a model is estimated and tested whether or not the model fits the data by exploring if the model significantly deviates from the data, using troublesome and much debated fit indices (Byrne, 2010; Ullman, 2007). In our case, it was unlikely that the model would pass the fit tests. Traditional SEM could still be used to give information on where the model could be improved to fit the data, therefore, running the model in traditional SEM could still be informative. In our case it was possible to use a Bayesian simulation approach to test the model. The Bayesian approach is considered to be more appropriate for smaller sample seizes and non-normally distributed data, as this approach is based on a different paradigm of 'true values' of variables in models. We decided to use both a traditional SEM and a Bayesian SEM to tease out which variables were worthwile to include in the model test, which was tested using Bayesian SEM, then we used traditional SEM to explore where possible improvements could be made to the model.

7.5.1 | Considerations for testing the model using Bayesian estimation

Bayesian estimation techniques represent a different mathematical paradigm from the frequentist paradigm on which traditional SEM and its hypotheses testing are based. In the frequentist paradigm true values of a model are viewed as fixed but unknown, and the estimates of those parameters from a given sample are viewed as random but known. If there are plenty of data points available, the true value can be approximated. In the Bayesian approach all unknown parameters are viewed as random, but they can be estimated based on a probability distribution and the observed data that is random but known (Arbuckle, 2012). In Bayesian SEM the full range of possible values in the population are estimated and the algorithm reiterates until the values stabilise, or converge, using simulation based on the probability distribution and the observed data. The software we used to simulate our model was Amos, which uses a Markov Chain Monte Carlo distribution to obtain the posterior distribution of the estimates (Arbuckle, 2012).

7.5.2 | Specifying and identifying the model

The preliminary analyses showed that some variables did not have any effects, while other variables showed promising results. These outcomes were combined with explorations of the model as a whole using traditional SEM and used to draw up the measurement model presented in Figure 7.3, which was based on the figure shown in Figure 7.2. These explorations were necessary to determine which variables could be removed from the model to create parsimony and free up degrees of freedom. The outcomes of these explorations are presented in Appendix 8.1 to A8.3. As reported in Appendix 8, we explored substructures of the complete model to explore the effects of the variables that emerged from the preliminary analyses. The output variable used in these explorations was the total number of credits students had obtained in their first year: EC Total. In Table 7.3 we show summaries of the outcomes of the preliminary analyses and the SEM explorations.

Table 7.3 | Summary of the reduction of variables based on the preliminary analyses of the data presented in Appendices 5 and 6 and on the SEM analyses presented in appendix 8.

Variable	**Results of analyses**	**Included in reduced model**
Dispostion ← Student attributes		
Age	No effects in Appendices 5 and 6	Not included
Gender	Effects in Appendices 5 and 6 Effect in SEM 2010: model fit deteriorates when gender is added	Not included
Aptitude	Mixed effects in Appendices 5 and 6 Effect in SEM 2010: definite effect	Included
Academic skills		Not included
Numerical skills	Effects in Appendices 5 and 6 Effect in SEM 2010: no effect	
Language skills	No effects in Appendices 5 and 6	
Prior education	Very small effects in Appendices 5 and 6	Not included
Retained in grade	Very small effects in Appendices 5 and 6	Not included
Parental level of education	Very small effects in Appendices 5 and 6	Not included
Impairments	Small, mixed effects in Appendices 5 and 6 Effect in SEM 2010: no effects	Not included
Science orientation	Very small effects in Appendices 5 and 6	Not included
PR total	Mixed effects in Appendices 5 and 6 Effect in SEM 2010: no effects	Not included
Housing situation	Very small effects in Appendices 5 and 6	Not included
Commute time	No effects in Appendices 5 and 6 Effect in SEM 2010: no effects	Not included

Variable	Results of analyses	Included in reduced model
Dispostion ← Student attributes		
Membership fraternity and Membership Total	Mixed effects in Appendices 5 and 6 Effect in SEM 2010: no effects	Not included
Disposition ← Perceptions of education environment		
The preliminary analysis showed mixed and moderate effects. Path was significant in SEM 2010.		Included
Student Behaviour ← Disposition		
The preliminary analysis showed mixed and moderate effects. Path was significant in SEM 2010.		Included
Student Behaviour ← Student attributes		
Many of the Student attributes showed some effects in the preliminary analysis, but none of the variables included in SEM 2010 showed significant paths to Student Behaviour.		Not included
Student Behaviour ← Perceptions of education environment		
Many of the Student attributes showed moderate effects in the preliminary analysis, but none of the variables included in SEM 2010 showed significant paths to Student Behaviour.		Not included
Perceptions of education environment ← Student Attributes		
The preliminary analysis showed mixed and moderate effects. In SEM 2010 we only tested the effect of SE Maths of education environment, but this path was not significant.		Not included
Perceptions of education environment ← Education Attributes		
Ed Attr had mixed moderate effects in the preliminary analyses in A5 and A6, and some variables had significant effects in the education systems that were analysed separately in SEM 2010, however, these variables did not have any significant effect in the combined model.		Not included
EC Total ← Behaviour		
Moderate effects in the preliminary analysis in A5 and A6. Significant effects in SEM 2010.		Included
Disposition ← EC Total		
Moderate effects in preliminary analysis in A5 and A6, but no effects in SEM 2010.		Not Included
Course effects		
This topic is discussed in section 7.5.6.		Not included

Note: to save space we clustered the disposition, behaviour and education environment variables. For a complete overview can be found in Appendices 5, 6 and or 8.

Study behaviour is represented by a latent variable that reflects the cluster of four study behaviour scales: discipline, load, deep learning and focus. These variables were parcelled based on the factor analysis presented in Appendix 5. The endogenous variables all have error terms that represent the residues in those variables that cannot be accounted for by the manifest variables that load onto them. Three latent variables and a manifest variable load onto the behaviour variable: the latent variables represent the clusters of education environment, education attributes and student disposition and the manifest variable, students' maths grades for their final UPE exams, SE Maths, serves as a proxy for aptitude.

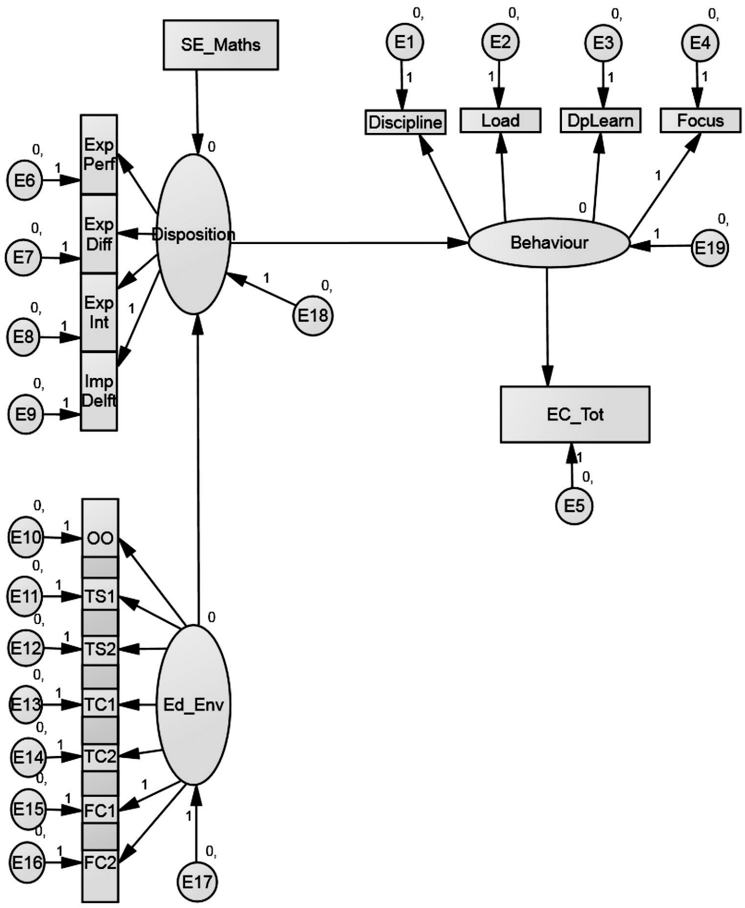

Figure 7.3 | The reduced measurement model.

For the 2010 cohort education environment loaded onto 7 variables representing aspects of the education environment. These variables were the weighed averages on the scales of teacher perceptions (TC1, teacher didactic competence, and TC2, teacher's openess), assessment perceptions (TS1, project assessment, and TS2, exam assessment), perceptions of facilities (FC1, facilities in general, and FC2, available student support) and of education organisation (OO), see also Table A5.3.4. The weighted averages of the perceptions of the education environment were calculated to free up degrees of freedom in the model and to deal with the missing data. A new variable 'expectation performance' was created out of the variables expectation BSA and Imp P as factor analysis showed that these variables loaded strongly on a single factor.

Some arrows representing relationships between variables had a fixed regression weight of 1. This is a necessary constraint of SEM, as at least one relationship needs to be defined for AMOS to estimate the other values in the equation. The regression weights for these relations did not form part of the output as they were not estimated. Tanaka (1987) reports the ratio between the number of cases and the number of estimates in a model, should be 20:1. Bentler and Chou (1987) believed this ratio was unrealistic and proposed a ratio of 5:1. In this study we achieved ratios of approximately 10:1, as is presented in A8.4.1 and A8.4.2. Kenny (2014) reports that a sample for a SEM model should contain at least 200 cases. In this study the ratio for cases to estimators falls within the range suggested by Tanaka (1987) and Bentler and Chou (1987) and it meets Kenny's requirement of having at least 200 cases (Kenny, 2014). We used non-informative priors for all the variables, which meant that nothing was known about the values and the estimates of the values in the model were based only on the data.

7.5.3 | Results of the Bayesian SEM on cohort 2010

We terminated the simulation as soon as the convergence statistic provided by the software dropped under its convergence threshold of 1.002, in our case at 1.0017 (Arbuckle, 2012). The main output of the Bayesian SEM is shown in Table 7.4.

The mean represented in the output is a summary statistic of the values each variable had in the samples analyses by AMOS and can be interpreted as an unstandardized regression weight. The standard error (SE) is a representation of the precision of the estimate. The standard deviation (SD) can be interpreted as the likely distance between the posterior mean and the unknown true parameter. The lower and upper bounds of the estimates represent those values within which the parameter should be estimated for 95 per cent of the simulations. Skew and kurtosis were no different from regular univariate statistics, and the skew and kurtosis in the output were still considerable.

The SEs were small for most values, except for behaviour→ EC Total. The standard deviation for this estimate was large. This could indicate that the outcome was a poor estimate of the true value in the posterior distribution. Arbuckle (2012) suggests that in such cases the trace plot of the simulation is consulted, to check for regularity, trends and or drifts. These are indicators that the estimate had not converged. The trace plots for disposition→behaviour, education environment → disposition, and behaviour→EC Total are shown in Figure 7.4.

Although these plots are not as regular as the plots of more stable estimates would be, and education environment → disposition and disposition→behaviour show some minor trends, we did not consider these trace plots to be worrisome. If that was the case, Arbuckle suggests that a model is too complicated to be supported by the data at hand and needs to be re-specified. The above is also supported by the low posterior predictive p-value that was found: .00, where a perfect model would have a posterior predictive p-value of around .50. This low value of the posterior predictive p was not surprising as the quality of our data was not good, due to a relatively low number of cases and the fact that we were trying to fit a complicated model.

Table 7.4 | Regression weights and means for reduced model using Bayesian SEM.

	Mean	S.E.	S.D.	C.S.	Median	95% Lower bound	95% Upper bound	Skew	Kurtosis	Min	Max
Regression weights											
ExpInt←Disposition	0.945	0.012	0.264	1.001	0.907	0.527	1.572	0.740	0.555	0.183	2.277
ExpDiff←Disposition	1.160	0.016	0.293	1.001	1.115	0.707	1.847	0.730	0.397	0.401	2.399
ExpPerf←Disposition	4.573	0.057	0.976	1.002	4.407	3.095	6.934	0.772	0.360	2.230	8.354
TC1← Ed Env	0.954	0.002	0.137	1.000	0.940	0.728	1.260	0.658	0.830	0.545	1.695
TC2← Ed Env	1.102	0.003	0.157	1.000	1.087	0.839	1.456	0.623	0.761	0.583	2.003
TS1← Ed Env	0.802	0.003	0.158	1.000	0.790	0.526	1.144	0.481	0.619	0.274	1.738
TS2← Ed Env	0.948	0.003	0.187	1.000	0.935	0.616	1.350	0.395	0.314	0.305	1.814
OO← Ed Env	0.643	0.002	0.102	1.000	0.634	0.470	0.869	0.531	0.402	0.312	1.139
FC1← Ed env	0.857	0.002	0.128	1.000	0.845	0.640	1.142	0.606	0.822	0.411	1.549
Disposition ← Ed Env	0.202	0.002	0.058	1.001	0.196	0.106	0.333	0.591	0.391	0.045	0.466
Disposition ← SE Maths	0.056	0.001	0.013	1.001	0.055	0.033	0.084	0.395	0.013	0.021	0.1115
Load← Behaviour	2.367	0.018	0.431	1.001	2.304	1.712	3.405	1.054	1.909	1.284	4.640
DpLearn← Behaviour	1.796	0.014	0.335	1.001	1.747	1.285	2.618	1.031	1.838	0.885	3.503
Discipline ← Behaviour	4.149	0.029	0.745	1.001	4.042	3.013	5.973	1.008	1.699	2.117	8.603
Behaviour ← Disposition	3.169	0.046	0.825	1.002	3.046	1.850	5.014	0.582	-0.095	1.197	5.970
EC total ← Behaviour	14.761	0.108	2.789	1.001	14.370	10.492	21.585	0.983	1.576	7.368	29.739
Means											
SE Maths	7.240	0.001	0.059	1.000	7.240	7.124	7.356	0.001	-0.064	6.999	7.478

NB: When simulation was terminated, (500+79.501)*16 itirations had been run. The results for the intercepts and variances are given in A8.4.

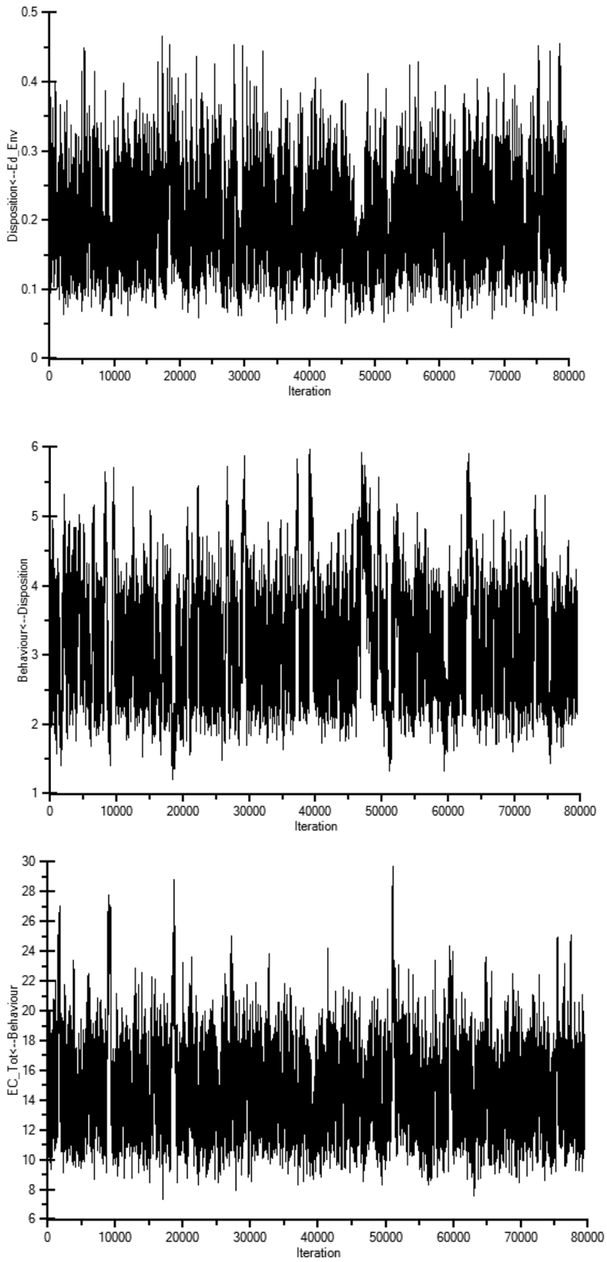

Figure 7.4 | Trace plots for cohort 2010 education environment→disposition, disposition→behaviour and behaviour→EC Total.

Making the model any less complicated was not an option: it would oversimplify a model for which there is ample support based on theory and observation and it would make the model uninformative for our purposes. Based on the fact that there was posterior convergence in the process and the trace plots for the troublesome relationships, and other relationships as well, did not show anything that was a cause for real concern, we assumed that the relationship between disposition and behaviour was complicated and that there was a large variation in how students were affected by this relation. This assumption was in line with the outcomes of the interviews.

We can see from Table 7.5 that the standardized direct and indirect effects of the main variables in the model were considerable. Keeping the weaknesses of the model in mind, the results given in the table show that the effects of aptitude, perceptions of education environment, disposition and behaviour for success are such that continuing efforts to increase things that are reflected in the scores of the variables is worthwhile.

Table 7.5 | Standardized direct and indirect effects of the major variables in the model.

	Disposition			Behaviour			EC Total		
	Mean	**95% Lower bound**	**95% Upper bound**	**Mean**	**95% Lower bound**	**95% Upper bound**	**Mean**	**95% Lower bound**	**95% Upper bound**
SE Maths	.342	.251	.429	.323	.234	.411	.186	.129	.245
Education Environment	.340	.230	.445	.322	.216	.423	.184	.122	.248
Disposition	-	-	-	.946	.853	1.038	.542	.454	.629
Behaviour	-	-	-	-	-	-	.573	.498	.642

7.5.4 | Results of the traditional SEM on cohort 2010

We ran a traditional SEM on this dataset using maximum likelihood bootstrapping and found the standardized values for the paths as shown in Figure 7.5. The rationale for this measurement model is included in Appendix 8 and the model shown in Figure 7.5 corresponds with the model in A8.3.2. A selection of the AMOS output for this run is included in A8.5.1. The fit indices showed that the model was not a good fit to the data. The chi2 was 359.666, with 117 degrees of freedom and a p-value of .000. A rule of thumb for interpretation of chi2 is that the ratio of the chi2 value to the number of degrees of freedom (df) should not exceed 2. In this case it clearly did. Another fit index is the root mean square error of approximation (RMSEA), was .062, which indicates a reasonable fit. The compared fit index (CFI) was .823, which indicates a weak fit. This indicated that the model was significantly different from the data. The paths in the model were also significant, which meant that none of the paths needed to be removed because they did not add anything to the model. The standardized residual covariances did not show any patterns of how the model could be improved. The modification indices showed that a path from education environment to EC Total would considerably improve the fit of the model, and a path from education environment to the manifest behaviour variable Discipline would also improve the fit. In addition AMOS advised that a covariance should be added between E5 and E3: the residual terms of EC Total and deep learning. This path was more difficult to understand and we did not add it to the model.

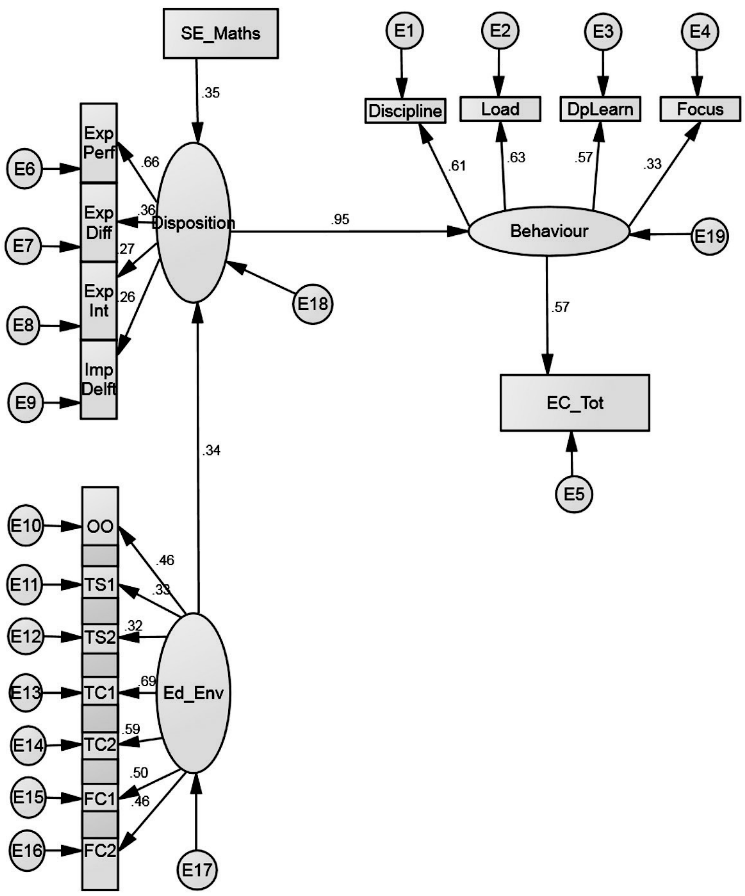

Figure 7.5 | Cohort 2010 standardized effects of traditional SEM.

We ran a model with a path from education environment to discipline. We found the following fit indices: chi2= 351.948, with 116 degrees of freedom and a p-value of .000. The CFI was .828 and the RMSEA was .062, so the model had a mediocre fit. This model is presented in Figure 7.6. A selection of the AMOS output for this run is included in A8.5.2.

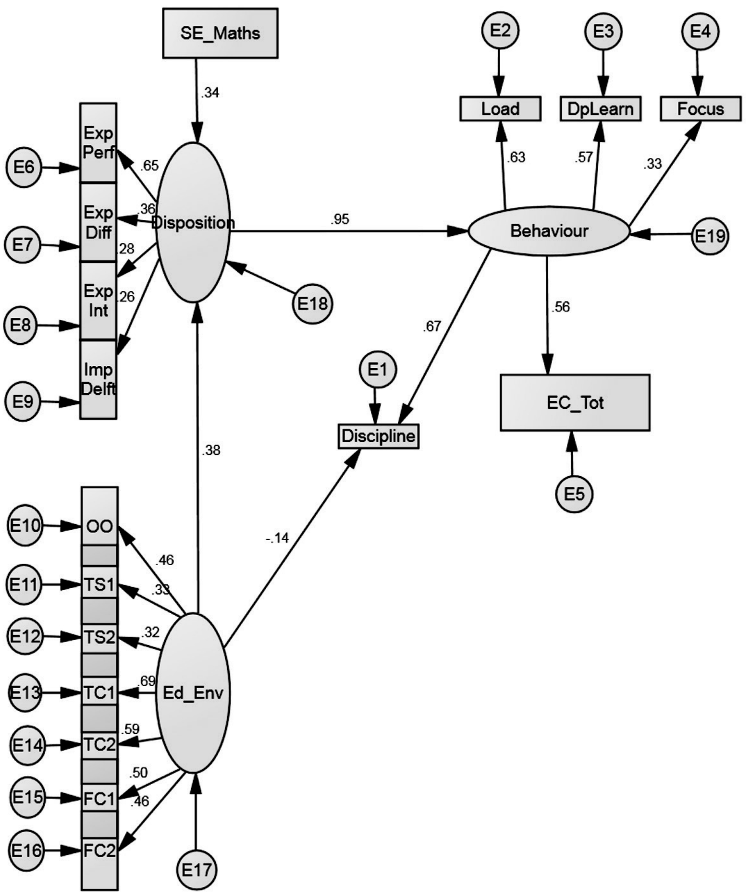

Figure 7.6 | Traditional SEM with an added path between Ed env and discipline.

Additionally, we ran a model with a path from education environment to discipline and from education environment to EC Total. Both of the added paths were significant in the model and the standardized effect from education environment to discipline was negative at -.19 and the effect on EC Total was negative at -.26. We found the following fit indices: chi2= 330.812, with 115 degrees of freedom and a p-value of .000. The CFI was .842 and the RMSEA was .059, so the model had a mediocre fit. The outcomes seem counterintuitive, and could have resulted from sensitivity to this specific dataset, but it is an interesting notion. It seems that students who have a positive perception, or experience, of their education environment are more laid back in their approach to studying and end up with fewer credits. The path from education environment to EC Total is not one that would fit an action-oriented model as it is not clear what this path represents. The negative path from education environment to discipline should be part of this model. The finding has a precedent as it is analogue to the finding of Jansen and Bruinsma (2005) who also found a negative relation between perceptions of the education environment and discipline in their model[17].

At this point it is not possible to claim that the directions of the arrows between, for instance, education environment and disposition or between disposition and behaviour are unidirectional relationships. It is more likely that when we consider the data, the direction of the relationship is bidirectional and changes in, for instance, disposition could also affect the perceptions students have of the education environment. In this model we base the assumption of the direction of the paths on the outcomes of the literature review and on the outcomes of the qualitative studies, but that does not necessarily mean that these direction cannot go in both directions when the data is examined more closely.

7.5.5 | Results of the Bayesian and traditional SEM for cohort 2009

We ran a Bayesian SEM on the data of the 2009 cohort, but AMOS could not converge the model. The posterior distributions of disposition→behaviour showed many trends and drifts, as did the posterior distribution summaries for other estimates. The traditional SEM showed a fit that was worse than the fit of the model to the 2010 dataset. The chi2 was 678.485, with 152 degrees of freedom and a p-value of .000. The CFI was .603 and the RMSEA was .084. AMOS showed that none of the variables loading onto disposition were significant, including SE Maths and education environment. Nor was the path disposition→behaviour significant. The modification indices showed that the model would fit considerably better if a path from education environment to EC Total was added.

This is interesting, as this path also emerged as a possible way to improve model fit for the 2010 cohort. We ran the model again with this path added and the model fit improved slightly, with a chi2 of 663.564, 151 degrees of freedom and a p-value of .000. The CFI was .654 and the RMSEA was .083, but it was still a poor fit. The standardized path coefficient for the added path was -.17, which was an outcome similar to the 2010 model with added paths. There were no covariates that could be added to improve the model and the standardized residual covariance matrix did not show any obvious way of improving the model.

The data on the 2009 cohort was collected when the students had just started in their second year of study and the students who had not passed the BSA threshold were no longer registered at DUT. It is possible that this population was already so far removed

[17] A notable observation is that the model that was designed based on this empirical data, in fact has many similarities to the descriptive model by Jansen and Bruinsma (2005) who included students' pre-entry characteristics, perceptions of the education environment and study behaviour in their model. Their model, in turn, has many similarities with the '3P-model' as reported by Biggs (2003), who recognized that the learning process could be described in three phases: the presage phase before learning that pertains to characteristics of the student and of the learning environment, the process phase which consists of learning focused activities and the product phase which pertains to quantitative, qualitative and affective outcomes. In the 3P model all of the elements of the model interact. We take the similarities of our model with two other models that seem to be independent as a sign of validity of our model.

from their first year experience that the data was not representative for this experience and that the first year model no longer fitted. We regard the 2010 cohort dataset as a stronger dataset of the two and we therefore attached more value to the outcomes of the analyses based on the data from the 2010 cohort.

7.5.6 | Differences between engineering, science and design courses

We set out with the intention of comparing the outcomes of the model for first year DUT student success for the various 'boxes' representing the core of the courses taught in DUT. These are engineering, sciences and design. It was found that the sample sizes for these groups were too small to run the model and that merging the datasets for cohort 2010 with the dataset for cohort 2009 was not viable once the model had been tested on both data files. We cannot make any definite statements on how the boxes differ in their scores and fit of the model, however, the outcomes of the preliminary exploration with basic statistical techniques are given in Appendix 7. The tables in this appendix show that there are differences in student behaviour, disposition, perceptions of education environment between students representing the various boxes and that these seem to occur most often between the design and engineering boxes. Further exploration of these differences is recommended for future research.

7.6 | Reflection and discussion

We set out to collect quantitative data to test the preliminary model proposed based on the outcomes of a literature review and Studies 1 and 2. We collected data from two cohorts using a questionnaire and linked the student data with data from existing sources such as a study guides and the university's central database. The response to both questionnaires was low: just over 20 per cent. The proportions of women and of students representing different faculties were comparable with those in the general population. The respondents had all obtained significantly more credits than the population average. At the time of collecting data, the students from cohort 2009 had already started their second year. Based on these observations, it is safe to state that the data that was collected was not representative of the population, as there were too many successful students present, thus possibly our data was a subset of successful students. This underlines the fact that, as a result of the circumstances, we found we were working towards a model to explain the success of successful students, and not the lack of success of students who are less or unsuccessful.

The initial exploration of the data revealed that the correlations we found were not as numerous as we had expected. In addition the correlations were moderate, although they had small p-values. This is an interesting notion, as this could mean that many of these variables had small but persistent effects on many of the students. The effects are subtle and their overall effects will be hard to detect in a larger model. Most of these variables had to be dropped to reduce the size of the model. This does not mean that the effects do not exist. As a result of the aggregation level, however, these results can no longer be detected (see e.g. Hausknecht & Trevor, 2010). It could well be that for some sub populations that have not deliberately been included in this research these relations would be stronger. In both datasets the information on time on task was distributed in such a way that we decided not to use the data, which meant we could not include this important variable in the model.

We found some differences between the two cohorts in our initial exploration of the data, which led to some differences in clustering of variables, such as behaviour. The questionnaire for 2009 had three more items than the 2010 cohort questionnaire, two of which pertained to the construct of education organisation, so it was not surprising that these variables led to a different outcome of the factor analysis. Based on the outcomes of the preliminary data analysis, however, we did not expect the large differences in SEM we found for the two cohorts. Bayesian SEM is designed to deal with 'difficult' data, but even so it proved to be impossible to converge the posterior distributions to something that made sense based on the non-informative priors and our observed data.

In spite of the difficulties and poor fit of the models that emerged from the SEM exercise with both cohorts, the relation between disposition and behaviour in both cases was especially troublesome and in both cases the suggestion was made by AMOS to add a path between education environment and EC Total. In the reasoning underlying our model, any relation between these two variables has to go through behaviour. Models that included a path between education environment and behaviour, however, showed that this path was redundant. The indirect effect of education environment to behaviour via disposition was approximately .2, but apparently there are other relations between environment and number of credits of which we were not aware. The other outcome was the problematic relationship between disposition and behaviour. From the interviews, especially those of Study 2, it was clear that this relation is not obvious to many students. Many of them are motivated to do their courses, but they get sluggish when it comes to opening books and sit down to study subjects they have trouble with, until they understand them. In the 2009 cohort the relationship between behaviour and EC Total did not converge, in the 2010 cohort the relation could be estimated with great precision, but the standard deviation was relatively large. The trace plot did not show too many issues though and the standardized effect was quite large. This led us to conclude that this relation needs to be verified using a larger data sample, and that this relationship probably varies considerably per student. It is not clear how this mechanism works, but it is clear that it needs, and deserves, to be studied in more depth. The same goes for the other two suggestions AMOS made to improve the model: a path from education environment to the manifest behaviour variable discipline and a covariate between the residual terms of EC Total and deep learning. The first suggestion could be interesting to pursue: the education environment could have a direct relation with a student's behaviours representing discipline, without this behaviour being part of a construct of overall behaviour. This is a notion that is supported by the interview outcomes of Studies 1 and 2, and by the outcomes of Jansen and Bruinsma (2005). They did not have any clear explanation for the negative path between these two variables. The other suggestion is more difficult to understand, as it concerns a residual term, between a behaviour variable and the residual of number of credits. At this point we are not clear as to what kind of relationship this could be: SEM is sensitive to the data that is used and it could well be that these suggestions pertain to the data, rather than to the model.

It is important to consider why fitting the model turned out such a challenge. First, the model could be wrong. This is definitely an option, as it is possible that in spite of the interviewing done with large numbers of students, important subtleties were not picked up on. In the literature review, however, we found a lot of support for the variables that were included in the model, and the relations that we believed were there were also supported by many studies. If we missed subtleties, they have probably also been missed by other researchers. The second option could be that our questionnaire was wrong: we may have asked the wrong questions or we asked at the wrong level of measurement. The questionnaire was tested on a limited number of students, who did not have any trouble with the questions. They did report that they felt the questionnaire was too long. We did not want to remove any questions, because we were looking for data richness, however, the length of the questionnaire could explain the relatively large number of unfinished surveys. What is a more interesting question is the level of measurement that was used. We were interested in learning about students' perceptions of their education environment. The issue with perceptions is, as we discussed in chapter 4, is that people can be in the exact same situation, but perceive it in diametrically different ways. Students generally agree on what constitutes a good lecture, but they all have a different perception of what is a good lecture or who is a good teacher. An interesting observation here is that in both cohorts the female students had a significantly different perceptions of their teachers and the education organisation from the male students. The questionnaire questions on perceptions of the education environment may have been measured on a level that was too close to the almost random ways students perceive their environment. Another issue could be that the scaling used for the answering categories was not fit for collecting the data, although the 5 point Likert-scale is used as a standard in the field of behavioural research (Cohen et al., 2011). It could also be that the explanations of the Likert-scale answers were such that the different students could interpret them differently.

A fourth option to explain the challenge of fitting the model is that we chose the wrong method of analysis: SEM places stringent demands on the data used: large sample sizes are a must, the method is sensitive to the data structure, and missing data and non-normally distributed data create serious problems when this method is used. Complicated models are difficult to fit because the more variables in a model, the more noise there is and the less shared variance remains for each path that is estimated. When variables are left out a model loses some of its value because it becomes less specific and informative. There is a trade off between the level of complication in a model and the potential fit of a model. In this research we were developing a model to describe what really goes on in the process of first year student success so the model could be used as input to understand the reality of student success, and as such be useful for the development of effective education policy. As SEM is the only linear technique that tests dependency relations simultaneously and that considers the residual terms in a model, SEM was the obvious choice for our model. Modelling methods based in complexity theory would be appropriate in our situation, as linear models do not perform well for models containing a relatively large number of variables and with relatively small sample sizes of non-normally distributed data. Such modelling methods can also be used to run subgroup analyses, which would help us to answer the question of whether there are significant differences when our model is fitted for the engineering, science and design boxes. I would like to note here that there is a definite advantage to modelling in addition to exploring relations on the level of separate variables. If researchers only sift through data files and study the significant effects, they will not become aware of any shared variance. They look at the variables without looking at the contexts in which the variables exist. This can potentially lead to incomplete or a wrong understanding of what is going on with the variables and the kinds of relations exist between them. Modelling is paramount to gaining more understanding of what we observe happening around us. Models can never include everything and a model is limited by the invisible boundaries of choices made a the researcher who decides what should go in a model and what can be left out (see e.g.: Sterman, 2002; Sterman, 1994). It is important for researchers and practioners to keep this in mind whenever they are trying to make sense of data: they are looking at a subset of variables that could have potentially been added to the model and not the absolute variable set of the situation, which is probably impossible to determine. The reasons why variables are left out range from ignorance of a variable through simplification to malign intent and anyone working with models should be aware of this phenomenon.

Another issue pertaining to the challenge to fit the model could just be sample size and it is possible that we did not do enough to reach out to the student population to get a higher response rate. Today's students are overasked when it comes to surveys and research. Some students said in their interviews that they never read official DUT mail, because there was too much of it. There is a tendency for a specific group of students to be willing to participate in this kind of research and based on our observations, students who have doubts about their abilities or choice of field, or anything else, tend to avoid participation in this kind of research. This problem needs to be addressed in future research, and if possible a solution needs to be incorporated in the design of any research strategy.

We recommend that our study is replicated using a larger dataset to fit the model to test where the problem with fitting the model lies. Until this time, we believe that the model is fit to work with, as long as the limitations we have outlined above are considered by the people who use the model.

Chapter 8

Study 4: The model for first year engineering student success and intervention praxis

8.1 | Introduction

In chapter 7 we described how we designed and tested the model for first year student success and found that the model was a mediocre fit with the data. The test showed us that the model was not yet as strong as it could be to inform policy developers, but, that although the model did not show a great fit, it should not be rejected based on the outcomes of the Bayesian SEM. In this chapter we will explore how a model like ours might be used in the practice of policy development. The research presented here was designed to answer the following question: How, and to what extent, will application of the reduced model facilitate our understanding of the outcomes of policy measures intended to increase student success at DUT?

We explored this question using a small number of case studies of interventions implemented in DUT to increase student success. These case studies and interventions are discussed below using the model as a framework. The DUT interventions we selected to this purpose were the introduction of the BSA, the implementation of modular education, or blokonderwijs, at Civil Engineering in the 1990s, and the recent implementation of the numerus clausus at Aerospace Engineering. We chose these policies because they reflect different elements of the model and because they are fairly well documented.

8.1.1 | The DUT model for student success revisited

Following the analyses reviewed in chapter 7, we discern between three possible relations in the model. As presented in Figure 8.1, weak relations are indicated with dashed arrows, moderate effects are indicated with regular arrows, and strong relations are indicated with a bold arrow. The arrows are accompanied by a plus or a minus sign to indicate whether the effect is positive or negative. Not all the relations included in Figure 8.1 were included in the model presented in Figures 7.5 and 7.6, but if there was a lot of support for the relation from the literature or from the preliminary analyses for the model, see Appendix 5 and 6, the relation is included in this model.

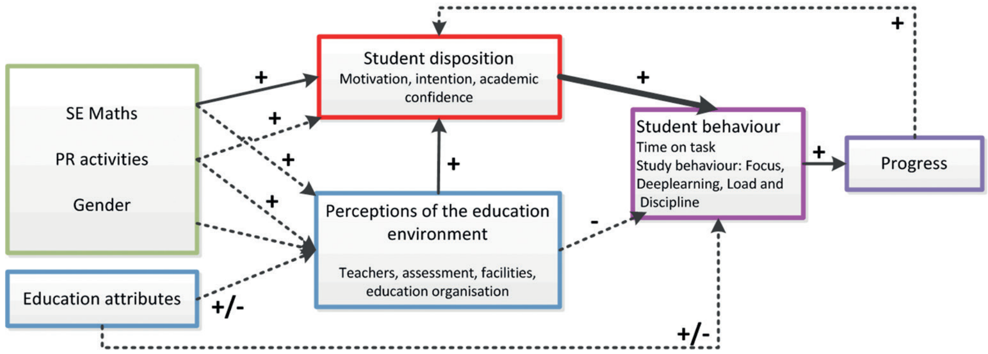

Figure 8.1 | Model for first year engineering education success.

The education attributes cluster was assigned a plus and minus sign, because in this case more is not necessarily better: increased contact hours, courses, exams and mandatory activities will probably not lead to more time on independent study or time spent on effective study behaviours. Gender affected the perceptions of the education climate, but there were no differences between male and female students' dispositions. The arrow from Gender to Perceptions of Education Environment does not have a plus or minus sign, but the arrow indicates that male and female students have different perceptions of their education environment. The number of PR activities students attended, positively affects students' perceptions of the education environment and students' dispositions variables. Two disposition variables pertained to students' expectations of the level of their course and the amount of interest they experienced while studying their course. It is easy to understand how these variables relate to the other: if students have participated in multiple PR activities on the campus, it is to be expected that these students have an adequate understanding of what the course is about and how difficult the course is. The relation between aptitude and disposition was tested in chapter 7 and it was found to be a robust relationship. From the prelimininary analysis, presented in section 7.4 and in Appendices 5 and 6, it is clear that there is a relation between aptitude and the perceptions of the education environment, however, this relation is not as clear and robust as the relationship between aptitude and disposition.

More research is needed to verify the strength of the relations we included in this model, but we believe that there is enough support from our research and the literature, presented in this dissertation, to support these relations as presented.

8.2 | Case 1: BSA

The DUT binding recommendation on continuation of studies or BSA was briefly introduced in chapter 2. Dutch universities are required by law to grant access to all students who comply with the admission requirements for the subject for which they are applying to study. Universities are in general not allowed to select student prior to enrolment. Instead, in the Netherlands, the first year of university studies is designated as a year in which to select students and refer them onwards if necessary. In general a student's departure in the first year is not seen as an issue. Students are free to go to all the open campus days organised at Dutch universities, but the proof is in the pudding: students need to experience a course to find out if it is for them. The DUT introduced the BSA in 2009. Before this the university did not have an instrument it could use to send away students who were deemed unfit for a particular course of study, thus the selection process usually came down to self-(de)selection by a student. In many cases students procrastinated their decision to leave their course, for instance because they found it difficult to accept that they were not up to it, because they did not see any other options, or because they were too well integrated in Delft life (see e.g. Technische Hogeschool Delft, 1959). De Gruijter (1996) argues that a BSA will only be successful if a few basic requirements are met by the course administration: the first year needs to be 'do-able'[18] and representative of the course, in both content and level. The exam requirements for the students need to be made clear well in advance and the exams need to be of a high quality. Finally the students need to be well supported by study advisors, tutors, etc.

The BSA rule requires that all first year students must obtain at least 50 per cent of the required first year credits to be eligible to continue with the second year of their courses, i.e. 30 out of 60 European Credits[19]. It was expected that this new rule would have major implications for the student experience, as a lack of progress would have serious

[18] The term 'do-able' is used here as a liberal translation of the word 'studeerbaarheid'. This word was coined by Professor Wijnen (1992) in the report 'Te doen of niet te doen'. The word was chosen as an analogue to the word 'gezondheid' (health), which is used to indicate that people may have health complaints, but that they can deal with them in such a way that the complaints do not hinder them in their daily lives. According to Wijnen, course designers cannot be expected to deliver perfect education and organise everything perfectly every time. Course administration can be expected to deliver a course that is taught and organised in such a way that problems that may occur can be solved in reasonable ways within reasonable timeframes (W. H. F. W. Wijnen, personal communication, December 2010).

[19] The BSA threshold was raised in September 2012, when it became mandatory for students to obtain at least 45 out of 60 European credits to be eligible to continue their studies.

consequences for a student. The anticipated effects included that students would devote more time to their studies in the first year and that students who were experiencing trouble would explore other options sooner instead of pursuing a degree that might be too hard for them. In the long run this should lead to less student attrition in later years and an overall shorter time to graduation for the student population at DUT.

8.2.1 | BSA from the perspective of the model

The elements of the model addressed by the BSA policy fall in the disposition and the behaviour cluster, and in the education environment cluster. The education environment cluster contains the conditions for a successful BSA, in terms of exams, factor TS2, and support facilities, factor FC2. When we look closer at these clusters, we distinguish the following variables.

Disposition

1. Expectancy regarding the level of difficulty students experience in their courses
2. Expectancy regarding how interesting students find their courses
3. Confidence regarding a positive BSA
4. Academic commitment
5. Institutional commitment

Behaviour

1. Discipline: behaviours reflecting the ability to keep up with classwork
2. Deep learning: tendency to focus on in depth understanding of the materials
3. Load: behaviour reflecting how students deal with large loads
4. Focus: behaviours reflecting how well students can concentrate on a task

Education Environment

1. Assessment
2. Student Support

In chapter 3 we presented an overview of the knowledge base on student success and student disposition variables, and how actual student behaviour played an important role in success. Of all the variables pertaining to success, the student related variables explain most variance. The disposition variables play a key role in this process. The BSA is therefore a measure that could lead to an increase of student success, as it is primarily aimed at influencing student disposition and subsequent behaviour. When we look closer at what student dispositions reflect, we see a wide variety of elements: confidence or a lack thereof, possibly resulting in fear of failure, academic and institutional commitment, and the extent to which student expectations regarding course difficulty and interest are met. When the pressure to perform and achieve is increased, as by the BSA, one would expect the academic commitment to increase, but at the same time one would expect academic confidence to decrease. From Studies 1 and 2 we know that early on in the year, students are not clear on what is expected from them. This creates tension, and a lack of confidence, which tends to go away once the first round of exams is over. When we look at the outcomes of the model shown in Figure 7.5 in section 7.5.4, we can see that academic confidence is the biggest contributor to disposition, so a lack of confidence will have consequences for the overall disposition of students.

For students who passed all, or most, of their exams in the first round of they first year exams, the pressure is off: they are already half way of the BSA threshold and see the rest as attainable – success breeds success. For students who did not pass some or most of their first exams, the pressure is on, because they need to deal with the pressure of resits, but also with dispositional pressures while, in most cases, they are dealing with lower levels of confidence. In Study 1 Hugo said that his confidence dropped dramatically after not passing his first exams in the first round and a student from electrical engineering in Study 2 said she was struggling in the first semester because she had to juggle so many things simultaneously, both academic and personal matters. She did not pass many exams, which increased the pressure on her to perform even more. In the second interview she mentioned that she still did not feel she had any control over her success nor did she have a lot of confidence that she would be able to pull it off. What she had going for her, was a strong motivation to want to try to succeed at electrical engineering. Isaac from Study 2 had similar feelings: he felt that many expectations were not made clear to him and it puzzled him that success seemed very random. Students whom he expected to be successful also failed their courses. This phenomenon was also observed by students from Applied Physics and Electrical Engineering: the relationship between how good someone was perceived to be and their success output, be it exams or grades, was very murky and frustrating to the students. Expectancy regarding a positive BSA and level of the course are also likely to drop in such a scenario. Institutional commitment and interest in the course, however, are factors that help students pull through (De Jong, 2012).

There were also students with other success intentions, for instance to have a rich student life experience. In Study 1 Matt from Mechanical Engineering and Abbey from Aerospace Engineering, in Study 2 Cliff from Civil Engineering said they went for the rich student experience, with plenty of extracurricular activities within the fraternity. Matt seemed reasonably successful in combining success in the academic and social arenas and seemed not to worry about the BSA. Abbey stated clearly in the first interview that she really enjoyed her fraternity and that she did not want to let go of this experience, but she did not persist in her course after it became clear that it was not for her. It is unclear if this was because of her involvement in the fraternity, but based on what the other students said about her, we assume that her fraternity life got in the way of her studies. A student from CE, also had trouble combining his fraternity activities with Civil Engineering, but at the time of the second interview he was still able to control the damage and adjust his strategy to get at least past the BSA threshold. The success intentions were widely varied among the students and it seems that the BSA is intended to address those students who maybe do not have their priorities sorted the way DUT, or in that regard wider society, would like to see it. For student who do have the right motivation, but who need more time to learn to master the subjects or who are off to a bad start, the BSA is probably an extra barrier. The result could be that able students will need to leave as a result of the policy, rather than as the result of a lack of progress or motivation.

De Gruijter (1996) discussed the importance of good quality assessments and student support. The need for good quality student support was also recognized by Croese (2008) who wrote an advisory report on the BSA and its implementation. She reported that in a recent study on student support facilities and the needs of students, 75 per cent of DUT students were satisfied with the quality and availability of the student support offered. The other 25 per cent, however, was not and it turned out that this 25 per cent consisted mainly of students who were delayed in their courses. This is worrying, as these students will need increased support after the implementation of the BSA. This is in line with the observations of Studies 1 and 2 that the non-persisters reported mostly negative experiences with student support officers. Based on Croese's observation, however, it is safe to assume that the student support services were left unaffected after the implementation of the BSA. The same goes for the quality of exams. This topic has not been studied in depth at DUT as far we know. Every course evaluation by students contains a question on the perceived quality of the exam, but there is no collated information available on examination quality and level at DUT. Within the university teaching qualification programme the topic of assessment is mandatory for all participants and was made so in early 2013. Some of the assessment and examination software packages used at DUT, such as Sonate, give teachers information about the quality of their tests, but only few teachers use such software and we doubt these Studies 1 and 2teachers are aware of this feature and if they use the information to improve their tests. In some faculties the topic of exam quality has been on the agenda for some time, but this is not the case in all the faculties. Croese (2008) does not mention exam quality in her report, and when we consider the number of times students participating in Studies 1 or 2 mentioned assessment, mostly in negative ways, we conclude that this topic was left untouched after the implementation of the BSA in 2009. When we look at the model and try to estimate what these observations mean for understanding the possible effects of the BSA, we assume that, as a result of students' experiences with the education environment over time, their perceptions of the assessment and student support facilities become more negative. This again feeds into disposition and influences the stability within this construct.

Based on the above observations, we concluded that disposition became less stable for students who were initially unsuccessful in their courses and were probably having negative experiences with their education environment. A student's determination to be successful may increase, but this may be undermined by diminishing confidence. For students who are successful disposition will not change or it becomes more stable, partly because reasons to feel insecure drop away and partly due to the relation between success and motivation.

In the model for success there is a strong relation between dispositions and behaviour. If scores on disposition stabilise or increase, effective student behaviours are likely to be continued or increased. If disposition becomes less stable or decreases as a whole, it will also affect behaviour, but it is not clear how. It could be that more time is spent on study, much like how Hugo and Marc dealt with catching up after failing some of their exams. They structured their time around a plan for their studies and stuck to their planning. It could also be that students adopt other strategic behaviours or become more selective in how they spend their time or what they spend their time on. In Study 2 students who were not very successful, adopted a strategy to pass the courses that were essential for their ability to continue to take courses that rely on knowledge acquired in previous courses. There were also students who became sluggish when they were confronted with a lack of success, and who did not seem to be able to transfer the wake up call from failure into effective study strategies and or more time spent on task, despite support systems that were in place. The link between behaviour and success is neither strong nor weak. In spite of all the behaviours and time students spent, they can still be unsuccessful, like Isaac and Clark from Study 2 who put in a lot of effort in the courses they found hard, but still failed.

8.2.2 | Effects of BSA

De Jong (2012) found that the initial results of the BSA are positive: students who were under the BSA regime obtained more credits than students from previous years who were undeterred by the BSA. De Jong did not report whether these differences are significant. She reports that in some courses the BSA had a direct effect that was visible after one year. In other courses the BSA seemed to have a delayed effect: the average number of credits obtained did not go up in 2009, but it did go up in 2010. De Jong speculated that this could possibly be due to the implementation of the Bachelor before Master Rule that went into effect that year, which could have added to the effect of BSA or to which the rise in credits obtained could be attributed. In some courses the number of credits obtained remained unaffected by the introduction of the BSA. In 2012 the BSA threshold was raised to 45 out of European 60 credits. Overall the number of credits students obtain in their first year has gone up (Technische Universiteit Delft, 2014), so it can be concluded that the BSA is successful, although it is not entirely clear if the effect is due to the BSA, the Bachelor before Master Rule, or other developments, such as the short-lived long-term student penalty, or langstudeerderboete, see Appendix 1. Our model for student success does not take such external factors into account, nor does the model take student finance into account and this is a topic of concern. In September 2015 a new system of student loans will go into effect and this system will increase the financial burden of studying significantly. This may mean that the model will have to be amended to account for these changes, at keast for some groups of students.

How does model help us to increase our understanding of the workings of the BSA? The model shows that addressing a single disposition variable can create instability in the disposition cluster, because the BSA itself and failure in particular can create frustration, lack of confidence and decreased motivation in students. This can be reinforced by negative experiences in the education environment, which occur regularly when we look at Studies 1 and 2 and at the report by Croese (2008). At the same time, the percentage of students who obtained their P-in-1 is on the rise: in 2003 only 20 per cent of the students obtained their P-in-1, but in 2012 this percentage was 34 per cent (Technische Universiteit Delft, 2014). It is possible that a measure such as the BSA has a negative effect for some students, but affects other students in a positive way. These students may have a stronger disposition, which in turn influences their study behaviour and success influences success. The model shows that if students have more academic commitment this will influence the study behaviour and it will influence student success, although there is not a one-to-one relationship between these two.

8.3 | Case 2: The implementation of modular education at Civil Engineering

In 1987 officers involved in the course organisation of Civil engineering experimented with the implementation modular education. Vrijman and Wasmus (1990) reported that way the course was organised led to ineffective study behaviour on behalf of the students. There were large numbers of weekly contact hours which prevented students from being able to spend enough time on independent study and there was too much time between the start of a subject and its examination. Students started to prepare for their exams only days before the exams and the pass rates were very low. Few students passed all the exams of a given term. The faculty implemented a schedule of modules of 4 or 8 weeks, with only 2 subjects scheduled simultaneously and the exams would take place in the final days of each module. The education within each module was structured using practicals related to the theory taught in the subjects of each module and which allowed the students to apply what they had learned. Feedback on the practical applications was prompt. The goal of this operation was to increase the time students spent on their coursework and decrease the time to graduation, to create opportunities for educational innovation and to increase the efficiency of the course.

8.3.1 | Modular education from the perspective of the model

When we revisit our model, it seems that this innovation pertains to education attributes and education environments, and their relation to study behaviour. The relation between education attributes and behaviour is part of the model, but the relation is unclear. The relation between education environment and behaviour only pertains to behaviours that reflect study discipline, but this relation is negative. When we consider these relations, disposition cannot be left out, as there is an indirect relation between education environment and behaviour through students' dispositions and this means that there is also an indirect relation between education attributes and behaviour though education environment and disposition. Disposition is also affected by other variables, such as a student's aptitude and within disposition the proportions between the variables can shift as a result of the changing input from education environment.

Disposition

1. Expectancy regarding the level of difficulty students experience in their courses
2. Expectancy regarding how interesting students find their courses
3. Confidence regarding a positive BSA
4. Academic commitment
5. Institutional commitment

Behaviour

1. Discipline: behaviours reflecting the ability to keep up with classwork
2. Deep learning: tendency to focus on in depth understanding of the materials
3. Load: behaviour reflecting how students deal with large loads
4. Focus: behaviours reflecting how well students can concentrate on a task

Education Environment

1. Assessment
2. Education organisation

Regarding the education experience, we would expect that the new schedule with fewer contact hours, more structure and increased alignment between subjects would create less fragmentation and influence a student's time on task and the effectiveness of their learning activities. Fragmentation was mentioned as a major peeve of many students in Studies 1 and 2, especially for the early part of the first year when there are many requirements and mandatory activities for the students. At another level, the students frequently brought up a lack of clarity of expectations regarding course goals and what they might expect of an exam. The new structure of the course could aid in providing more course clarity and a focus for the students, as subjects would be taught over a much shorter timeframe so it would be easier for the teachers and the students to keep their eyes on the ball. In this new structure students would be able to spend their 'budget' of time designated for each subject over a much shorter time frame which should allow them to gain more in depth knowledge of a subject much more quickly and, hopefully, more easy. This fits in with students reporting in the interviews that they felt a need to focus longer, to spend uninterrupted stretches of time on a single subject to allow them to grasp it. From the literature it is clear that there is an optimum for the number of scheduled hours each week and that if too many hours are scheduled this will take time away from the weekly budget of hours students have for independent study (Van der Drift & Vos, 1987). Students will probably have higher requirements of their education environment: feedback on assignments and exams will be more important, as will be the facilities in the labs and group works spaces and the spaces in the faculty where students spend their time studying between classes. As we mentioned in the case on BSA, many students reported negative experiences with assessment and the overall quality of exams at DUT is not an issue that has received a lot of attention over the years. In our model we included facilities for independent study, but not the facilities used for regular education activities, such as the lecture theatres.

We would also expect that students who experience their education environment in a more positive fashion, will have more favourable and stable dispositions: they will have more time for studying, they will get more feedback and, hopefully, have more success experiences. This could aid in developing more confidence, and in better matches with student expectations regarding the difficulty with, and interest students have, in their course. The modular policy was set up to create conditions for students to develop more effective study strategies and spend more time on task. Based on the model, it seems likely that these goals were achieved.

8.3.2 | Effects of modular education

From the evaluation of the introduction of modular education in the first year of CE by Vrijman and Wasmus (1990) we learn that students reported that the modular schedule coaxed or pressured them into studying. They did not mind this too much, but they had not expected this based on the information they had received on campus days and from other students. This is not surprising, because the older students heading the campus day groups had no experience with the new set up. The students were not happy with the scheduled hours for independent study, this often did not fit with their personal rhythms and there were not enough spaces for students to study or work on assignments. As a result these hours were experienced as fragmentation of time, rather than as an opportunity to study. The students complained that they had too little time to work on their maths assignments to learn to master the topics. Project education should not be scheduled in 4-week modules because it was too short to accomplish anything.

The students appreciated the variety in subjects and teaching and learning activities that were scheduled in parallel. This variety helped students to stay motivated, also for the subjects students found tough or boring. Vrijman and Wasmus (1990) compared the amount of time students spent on their studies in the modular system with the amount of time spent by students from the years before the implementation. They found that in both cases students spent less than the nominal, scheduled time, but the students under the new regime spent 20 per cent more time on their studies than students from previous years. The pass rates of the exams went up by between 6 and 30 per cent, also for the bottleneck courses with traditionally low pass rates. A notable effect of the implementation was that students complained that their schedules deviated a lot from those of their peers in other courses. This created problems in the social environments of the students, because they could not always easily participate in activities at associations that were geared towards the traditional schedules in the other faculties.

Snippe and Wasmus (1993) evaluated the modular education at CE after it had been implemented for all years at CE. They found that many students appreciated the structure of the modular schedule, but that many of the students failed to take the exams at the end of each module. In many cases the students were not allowed to take part because they had not done the necessary assignments that were a condition for taking part in the exam. The reason students gave for this is that they had too little time to get everything done. They also stated that they did not share the administration's goal of quick progress through a course. It is likely that the course do-ability was vastly improved by the implementation of the modular course set up by creating more favourable boundary conditions for students to be successful. Do-ability is, at least partly, in the eye of the beholder. A course can look do-able on paper, but that does not mean it is do-able in practice or that the students perceive the course as do-able. Students who participated in Studies 1 and 2 regularly reported that the course load was disproportional to the number of credits that was awarded for the subjects. Even if a course is do-able according to administrators and teachers, students may still feel as if too much is demanded of them and this has a negative effect on how student perceive their education environment and on their dispositions, and on their progress. Snippe and Wasmus (1993) did not report on the time students actually spent on their studies. It cannot be verified whether the students continued to spend an increased amount of time on task as reported by Vrijman and Wasmus (1990).

The effects of modular education at CE that were reported by Vrijman and Wasmus (1990) and by Snippe and Wasmus (1993) fit in well with outcomes of the literature review. Activities for orientation on a field of study matter and they are reflected in the students' expectations regarding the level and amount of interest students experience once they are enrolled in the course. The proof of the decision regarding choice of academic field still is in the eating of the pudding: students know they have made the correct choice once they are enrolled and experience what it is like to them. Another issue here is the reproduction of campus culture through learning from previous cohorts of students. Snyder (1971) described this phenomenon in his book on the hidden curriculum, situated at MIT, where he claims that, because of the overload students experience, students inquire how students from cohorts that have gone before them, survived. These older students will tell the new students about the tricks of navigating the demands of a course and in doing so, they keep up ways of studying that may lead to survival, but not necessarily to a set of projected learning gains. In the case of CE this tradition was broken by implementing a structure that was so different from what older students were used to, that the new students had to determine what was needed to be successful by themselves. At the same time, the implementation of the new structure did not lead to an overall decrease in time to graduation, as students were not interested in graduating sooner than they did. It is not clear if the initial results as reported by Vrijman and Wasmus (1990) of increased time on task and higher pass rates for exams, were still observed by Snippe and Wasmus (1993) three years later. The importance of the students' social environment also surfaced in this case. As student life in Delft revolves around the associations, a deviation from regular class schedules creates tension for students as it will take more determination, from the disposition cluster, to continue to make choices that benefit their progress, rather than their social experiences as social experiences are also a condition for studying effectively. The importance of the social environment should not be overlooked by policy makers, as it was in this case.

The outcomes of the discussions of the implementation and evaluation of the BSA and the modular education at CE show the importance of student dispositions: if students are not interested in progressing through their studies fast they will probably not do so, in spite of the conditions created in their environment to promote this goal. Students who have the intention of progressing fast will benefit from optimal conditions in their environment. The attributes and organisation of the course do influence the amount of time students spend on their studies and students report a positive attitude towards this way of organising education because they felt it was easy to keep up with the subjects. It is likely that with the implementation of the modular structure the do-ability of the course at CE was vastly improved. It may also be that prior to the implementation of the modular structure, the students also had little intention to progress through their course quickly, but the organisation of the courses may have prevented them from being any more successful. At least briefly after the implementation of the modular education, there was an increase in the amount of time students spent on their courses and the pass rates of the subjects rose. We believe this is an important notion, because often when education is innovated, there is a short-term surge of success that disappears after a few years. It would be interesting to find out how much time students at CE currently spend on their studies and compare this with the data found by the Propedeutic Evaluation Committee (Propaedeuse Evaluatie Kommissie, 1977) or those found by Vrijman and Wasmus (1990).

8.4 | Case 3: Implementation of *numerus clausus* at Aerospace Engineering

In 2012 Aerospace Engineering introduced a *numerus clausus* for the admission of first year students. The number of students wishing to study aerospace engineering had increased over the years to such a level that the quality of the education was under pressure. In implementing this policy, the number of students entering the first year could be set at a number that the faculty felt it could manage and guarantee high quality education, and by doing so, increase student success. The AE faculty traditionally has had a large attrition rate of approximately 45 per cent in the first year (Technische Universiteit Delft, 2014), while the university administration has strived for a maximum first year attrition rate of 22 per cent for all faculties in DUT (Technische Universiteit Delft, 2010). It was hoped that selection prior to registration would play a role in lowering the attrition rate for the first year of AE.

It was decided that selection for Dutch UPE students would be based solely on UPE grades. The rationale for this was that AE is a tough course and that only the best students from UPE would be able to meet the course requirements in a reasonable amount of time. The selection process was carried out by the Dienst Uitvoering Onderwijs, the office for organisation of higher education at the Ministry of Education. This office is in charge of the *numerus clausus* lottery for all designated courses in the Netherlands, including medicine. The lottery is a weighted lottery, which means that the higher the average grade a student obtains on the UPE exams, the higher the chance that she or he will be admitted to a course. Students who obtain an average of 8 or more out of 10 in the correct pre course UPE subjects are admitted automatically. All the students with lower grades are assigned to brackets and the higher a student's the bracket; the more chance a student has to be admitted to a *numerus clausus* course. Generally, this rule is seen as fair, as there is no bias in the selection based on other factors but aptitude.

A potential side effect of this policy is that students will have more institutional and course commitment and motivation because they are part of a special group. This idea is reinforced by the fact that students can only apply for participation in one lottery each year and medicine uses the same lottery-based admission procedure. Traditionally, AE attracted many students who had not been granted admission to medicine. These students are now forced to choose a course prior to registering for the lottery. It was expected that by admitting only highly motivated students with a high aptitude, the student success rates at AE would increase. Additionally, in September 2012 the BSA threshold was also raised from 30 to 45 credits in the first year to increase the effects of the BSA.

8.4.1 | *Numerus clausus* from the perspective of the model

This use of a *numerus clausus* policy at AE addressed only one variable in the model directly, which is aptitude. This variable was operationalized in a similar fashion to that of our model: the final maths grade for UPE. Indirectly the selection policy is expected to address student disposition, as motivation and commitment to the course and the institution are expected to increase.

Based on our model it is expected that disposition affects behaviour and as the students taking the AE course will have a higher initial aptitude, students are expected to be more efficient at studying, or to need less time to learn to master their subjects compared to pre *numerus clausus* students. It is expected that the change in selection, disposition and behaviour will result in the AE students obtaining more credits. The relation between aptitude and student success has been included in many studies, as is presented in section 3.5.1.2 of this thesis. The outcomes of these studies are mixed, aptitude seems to have some effect on student success, but students with high aptitude leave engineering courses just like students with lower aptitudes. Torenbeek, Jansen and Hofman (2011) found that the transition from secondary education to higher education is not at all clear and that many students have trouble adjusting to life in university. This issue was also brought up by students from Studies 1 and 2 who reported that effects of the transition are not evident in many ways, from the need to find a space to live, to the pace of the curriculum, and the way teachers teach, and so on. If a student gets off to a bad start for whatever reason, they will also get into trouble with their course work. In the model presented in chapter 7 we found a robust relationship between aptitude and disposition and an standardized indirect effect of aptitude on the number of credits obtained of .189. It is possible that students with high aptitiude who leave engineering do so for reasons different from students with a lesser aptitude, but students with greater aptitude tend to obtain more credits in the setting of our research. As we have argued at various places in this dissertation, life often gets in the way of student success but aptitude is an important factor for success.

The issue of pre selection for a specific course has not been studied in depth in the Netherlands, except for medicine and other health related courses that had a *numerus clausus* in place. It is assumed that the fact that students have been selected, creates a bond between those who have been selected. This is analogue to the situation in highly selective universities in the USA, where it is assumed that the feeling of being part of an elite is motivating for students and creates an institutional commitment that has been included as an important factor in several models for students success, including the student integration model of Tinto (1975, 1987).

8.4.2 | Effects of *numerus clausus* at Aerospace Engineering

At the time of writing this chapter there was data available on cohort 2012 with respect to the *numerus clausus*, not for cohort 2013. The 2012 cohort was considerably smaller than the 2011 cohort, when students were still admitted based on their prior education. In 2011 475 students were admitted to AE, of whom 320 held a UPE diploma, while in cohort 2012 328 students were admitted, of whom 211 held a UPE diploma. This number did not reach the maximum number of students to be admitted in 2012, which was set to 440, as a result, there was no *numerus clausus* lottery and all students with the correct pre university education gained a place in the AE first year. It can be assumed that some of the potential students had already self-(de)selected themselves for the course based on the sheer fact that there was a *numerus clausus* lottery in place.

Of the 211 students who registered as first year students in AE in 2012 and who had a UPE background, 116 continued their studies into the second year. That means that the attrition rate of UPE students in that year was 45 per cent. In total 21 per cent of the students did not persist and 24 per cent of the students received a negative BSA recommendation. The percentage of students who did not continue in their second year at AE was 41 per cent in 2010, 44 per cent in 2011 and 36 per cent in 2013.

It is striking that the attrition rate of 2012 was as high as it was, as it was virtually the same as for previous years when the *numerus clausus* lottery was not in place and when the student numbers were much larger. Although the lottery itself had not taken place because of the relatively small number of enrolling students, it is likely that the self-selection of students prior to enrolment in cohort 2012 was stronger then for the previous cohorts. Based on that assumption it can be argued that the *numerus clausus* was successful. At the same time, the percentage of negative BSA recommendations in 2012 was comparable to those of previous years, while the threshold was considerably higher than it was in previous years. This phenomenon is not new: De Groot (1970) reported that grade distributions and pass rates in schools are persistent over time, in spite of any prior selection. He reported that in any school in the Netherlands, regardless of type or level, attrition is approximately 25 per cent. There is no formal policy to enforce such pass and fail rates. De Groot argued that the fail rate was attributable to the system, rather than to the students and "that the consistency in failure rates and grade distributions are the result of constant, involuntary, comparative assessment procedures, grading and decision making [by teachers] (De Groot, 1970, p. 115)." De Groot argued that selection in Dutch education had no effect because of this pervasive phenomenon. In 2013 the student attrition rate at AE has dropped, which is what would be expected based on the *numerus clausus* admission policy, but it might be due to changes made in the course of the year that could influence this success rate. It remains to be seen if the pass rates will continue to drop.

Out of the 116 students with a UPE background that continued their course at AE 60 students obtained their P-in-1, compared to 36 in 2011. The UPE grades of these students cannot be verified at this time, but it would be interesting to determine if these were the students with the highest maths grades. While the attrition rate remained unchanged in 2012, the success of the students who continued increased. It seems that there have been separate processes going on, possibly with different subsets of students. Based on the interviews of Studies 1 and 2, we know that students who register for a course tend to have different goals, but with the BSA threshold raised and with a *numerus clausus* lottery for admission, it is likely that the success intentions of all the students were quite high. It is possible that the pressure to perform may have been too high for some students.

Some students may have been triggered by the selection and the pressure of the BSA to perform and obtain their P-in-1. For other students the selection may not have had that much effect, as the relation between disposition and aptitude is not very strong and it is possible that the selection combined with the BSA threshold may have caused unanticipated side effects. It is possible that students felt more pressured to perform, leading to diminished confidence or even anxiety, or to disappointment regarding the level of the course or regarding to how interesting students find their course, as they have relatively little time to immerse themselves in the subject matter, and so on. This destabilised disposition could possibly result in less effective study behaviour, concentration issues, and so on. With greater aptitude, effective study behaviour does not necessarily follow. Often the students who have had little or no trouble getting through UPE lack the work ethos that is necessary at DUT and specifically in AE, which has the reputation of being one of the toughest courses taught in the Netherlands. If students have trouble getting started and developing good study habits early on in the year, it will be tough to catch up and to pass the 45 credit BSA threshold: many students who fail to catch up in the second term have no way of passing the 45 credit threshold. In Study 2 a number of students mentioned the seemingly randomness of success. Students in AP and IDE reported that they did not understand how some of the most talented among them, scraped by the maths exams. A student at EE who was considered to be talented by his fellow students, reported that he worked harder than he had ever done, but still received poor grades or failed exams all together. The steps from aptitude to obtaining credits contain a lot of noise.

When reflecting on the AE *numerus clausus* case, it is hard to understand what has been going on in AE with the implementation of the *numerus clausus* and how this could have resulted in the contradictory results of high success in terms of P-in-1 and lack of success with the high attrition rates. The simultaneous implementation of the raised BSA threshold is unfortunate, as it makes it much harder to understand the effects of the *numerus clausus*. At the same time, the model shows that there are many barriers between aptitude and actually obtaining credits, and although pre-selection may have effects for some students, it may not have the same or any effects for others. The attrition rate of AE dropped in 2013 and it is to be hoped that this trend will continue. The topic of *numerus clausus* needs more research to learn about its effects and to learn if it leads to more student success on the longer term.

8.5 | Reflections on the DUT model for student success

The three cases discussed in this chapter all fit the DUT model for first year student success, which we take as a positive sign for the validity of the model: topics and processes that are present in the university can be put into place and into a narrative of what may be happening. Many of the side effects we observed in the cases are supported by the findings of Studies 1 and 2. We observe that the core of the model, the dynamic between education environment, disposition and behaviour, is relatively easy to understand, eventhough single variable measures may still impact groups of students differently (see e.g.: Cragg, 2009; Hausknecht & Trevor, 2010). Once multiple elements of the model come into play, it becomes more difficult to explain the possible effects of policies using the model. This is partly due to the fact that each variable has a certain amount of error and leaves large parts of the next variable unexplained. It is also partly due to the fact that policies sometimes have too few or too many potential consequences. For example, the BSA threshold of 30 credits did not lead to the projected effect size, but increasing this threshold to 45 credits forced some students who were not successful enough in the first semester, to give up. While the 30 credits threshold may not have been enough to put pressure on a large enough groups of students, the 45 credits threshold may give groups of students too much pressure to be able to perform. Unfortunately, the model does not aid our understanding of how much pressure is enough.

If multiple measures are implemented simultaneously, the DUT model of student success shows that these measures should not be contradictory. Measures that can lead to a diminished score in, for instance, the education environment cluster, might cancel out effects of a measure that addressed the disposition cluster.

The DUT model of student success is based on group level analysis, which means that it is best suited to explain the effects of measures on the level of subsets of the population. The model will not be very useful for helping us to understand how things work out for individual students. Although the DUT model of student success includes a relatively large number of variables that pertain to a large variety of elements in the university environment, it also excludes many variables that may be meaningful to individual students. Therefore we encourage the people who will use this model to familiarize themselves with the outcomes of the preliminary analyses presented in chapter 7 and in appendices 5, 6 and 7 to get a feel for the more subtle effects of the variables that were not included in the reduced DUT model, but that were included in the preliminary model.

Hausknecht and Trevor (2010) found evidence that effects at lower levels of a population tend to disappear when the data is aggregated on a higher level at the population.

It is clear from the exploration of the preliminary and reduced models of student success in chapter 7 that there are relationships in the model that we cannot explain well. For instance the negative relationship between education environment and the students' discipline to keep up with their course work, and the relationship between education environment and credits obtained by students, are not mediated by student disposition and behaviour. It will require dialogue within the university and further study to explore the factors that affect this relationship and how it works to complement our action-oriented DUT model for student success.

The DUT model of student success is used to describe success and not the lack thereof. We are not sure how this model pertains to the experiences of non-persisters. It is possible that the proportions of how much the variables contribute to the clusters are different for these students, but it could also be that a model for non-persistence would include a different set of variables. What the DUT model of student success also does not allow, is predicting outcomes of policy measures in quantitative terms. In its current form it facilitates the exploration of potential effects of policies intended to increase DUT first year student success, and as such, promote and enable meaningful dialogue on student success in Delft University of Technology.

Chapter 9

Conclusions, reflections and recommendations

Student success is among the most widely researched topics in higher education. Many of the models that have resulted from this research, however, have not impacted education praxis in terms of any visible changes in graduation rates, or other measurable quantities representing student success. In this research we specifically worked towards a situated model for first year engineering student success with an action perspective, so it could aid in understanding and explaining student success and as such, could be used as a tool for understanding and designing educational policy. We posed four research questions to achieve this. In this chapter we look back at the studies we have done to find answers to those questions and we discuss the outcomes in the light of the research goal and in terms of contributions to the field of student success research.

9.1 | Conclusions

The first question that was posed in this research was: which variables are related to success for first year engineering students at DUT and how are these variables related? This question was the subject of Studies 1 and 2, which were presented in chapters 5 and 6. In Study 1 the students reported that they have different ideas of what success could mean in the context of university engineering education. These ideas range from achieving personal goals to obtaining P-in-1. From the interviews it became clear that the culture in DUT has similarities with engineering culture as reported by Seymour and Hewitt (1997). They observed that engineering is competitive and that there is a 'weed out' culture which is not supportive to all students, and as a result students, including able ones, leave their courses. Students reported which variables they deemed important to their own success and how they were related. We clustered the important variables and found that the most important clusters were: student behaviour, including study behaviour and strategies and time on task, student dispositions including motivation and performance orientation, perceptions of the education environment, including perceptions of teachers, assessment, education organisation and facilities, education attributes, such as number of lecture hours and exams, and the students' social environment. Some students mentioned student background variables such as aptitude. Students found that their social environment is conditional to their success, but not the most important. The elements from the education environment that were found to carry most weight, were curriculum organisation, including the spread of course load and the quality of the materials and teachers' didactical competence. As discussed in chapters 5 and 6, many of these variables were found to be of importance in the literature review also.

Conclusion 1: *first-year engineering students in Delft University of Technology identify behaviour, disposition and elements of the education environment as important for their success. The social environment is found to be perceived as conditional for success, but does not have a direct influence.*

Study 2 was done to validate the outcomes of Study 1, but it turned out to be hard to get to the same depth of discussion and insight in this study. In the end, we did not gain many new perspectives from the students who participated in this study. For reasons of validation this was a good thing, however, it was also slightly disappointing as we got to talk to a large number of students. This is probably due to the scale of the study, where we had too few opportunities to engage on the individual level with students, and, possibly, too few opportunities to create an environment that was safe enough for the students to express their ideas on sensitive topics freely. We believe that the group interview format worked very well in all the studies, but we found that the larger the group, the more difficult is was to get to the heart of the matter. The stimulus objects were very useful in the interviews. They served as a focal point to the students and that made it easier for them to bring up their own ideas. The stimulus objects were formulated in neutral terms and language, which we believe helped decrease bias in the conversations. The modelling workshops were very successful. The set up, designated stimulus objects and 'model specs' were clear and worked well. The clarity and reasoning behind the relationships identified by the students proved to be very useful for this research. We could not possibly have reached the same level of understanding of student success without these qualitative sessions.

Conclusion 2: *group interviews, stimulus objects and workshop formats work well to collect high quality in depth information in this field of research.*

In Studies 1 and 2 we also found that the non-persisting students reported experiences that were similar to the literature on non-persisting in engineering, but that were different from the students who persisted. We will expend on this topic further down below.

The second research question was: which relations between independent and dependent variables in the model can be established for the population of first year DUT students? The data necessary for testing the model had been collected with the use of a questionnaire that was based on the outcomes of Studies 1 and 2 and the literature review presented in chapter 3. The questionnaire contained items on students' perceptions of the education environment, their behaviour, their disposition and a number of student background variables on which no information could be extrapolated from the DUT student database, with which the questionnaire data was linked. The questionnaire was filled out by students from cohorts 2009 and 2010. There was a response of about 20 per cent and the sample was representative for the wider cohorts in terms of gender and courses students were enrolled in. The sample was not representative for the number of credits students obtained: the students in the sample obtained significantly more credits that the cohorts as a whole.

We performed basic statistical analyses on the data, such as correlation analyses and significance tests, and found that many variables showed small correlations, with very low p-values. When these variables were included in the structural equation model, they had to be dropped because they did not add significantly to the model. The reduced model included most of the behavioural variables, all of the education environment perception elements, and most of the student disposition variables. The only student background variable that was included in the final model was aptitude, which was operationalized with the final grade for maths in university preparatory education. Overall, the model fit was mediocre, but it is unclear if this was due to poor data or other factors. The outcomes of the analysis suggested that the model fit would be improved if a path would be added from education environment to progress, i.c. credits obtained in the first year. We chose against this, because it was not clear what such a relationship could represent. The other relationships in the model were backed up with information from Studies 1 and 2. It would be interesting to pursue the relation between education environment and total number of credits obtained further and to explore what else DUT could do to influence its students' success. In the action-oriented model that was developed in this research student background variables such as aptitude played a minor role in explaining success. The relationship between students' perceptions of the education environment was of considerable strength and the total effect of education environment on EC Total was promising in the sense that this proved that universities do have influence on the number of credits students obtain. The student disposition variables took centre stage and the total effect of disposition on the number of credits students obtain was considerable. The relationship between behaviour and the total number of credits obtained could not be estimated very precisely, but it is a strong relationship.

Conclusion 3: *the Delft University of Technology education environment has an indirect influence on their students' success via the students' dispositions and behaviour.*

It is a misconception that persistence and non-persistence are mirror images (Tinto, 1987, 2012), in spite of the fact that persisters and non-persisters struggle with much of the same issues during their courses and name the same factors as impeding to their progress. Our intention was to involve many non-persisters in our studies to compare experiences and find out if the model we were developing, could be used to understand success and lack thereof. This intention failed, because it proved to be impossible to involve more than 7 non-persisting students in this research and because the data sample used in the quantitative study was skewed in the sense that the students who participated had obtained significantly more credits in their first year than their cohort as a whole.

Conclusion 4: *the model for first year engineering student success is limited to those students who persist.*

The third question was: what are the differences, if any, which can be established between students from the Science, Engineering and Design courses in the reduced model? A lot of research has been done on the differences in cultures across and within disciplines of science. In engineering there are differences between the fields of engineering, for instance, the culture and atmosphere at applied sciences are different from those are mechanical engineering and from those at architecture. These differences have been recognised by DUT officers and they have created three 'boxes' to cluster similar faculties together. These three boxes are science, engineering and design and they are used for instance for the way the faculties are financed. We expected to find differences in education attributes, based on the differences between the boxes and the foci for the courses the boxes consist of. We found significant differences on the number of participatory teaching and learning activities, exams and mandatory activities. Courses in the design box had significantly more participatory activities, and fewer exams and mandatory activities than the engineering and sciences boxes. The science box had significantly fewer exams and more participatory activities than the engineering box. We believed that we would find differences between the boxes with regards to their students' success. Unfortunately, the dataset contained too few records to take this exploration beyond the level of descriptive statistics. In the descriptive statistics we did find a number of differences. Again, these differences tended to be small with low p-values, so it could be that these differences are not significant in the model. It was found impossible to establish significant differences in the model, because of the small number of cases in the dataset. It was clear from the correlation analysis and the significance testing we did, that there are differences between the boxes in terms of perceptions of the education environment, student disposition and student behaviour.

Conclusion 5: *although effects could not be tested using structural equation modelling, there is reason to assume that there are differences between students from the different Delft University of Technology faculties, 'boxes', that affect their perceptions of the education environment, dispositions, behaviour and, possibly, the number of credits they obtain.*

The fourth question was: how, and to what extent, will application of the reduced model facilitate our understanding of the outcomes of policy measures intended to increase student success at DUT? We presented the model that resulted from Studies 1, 2 and 3 in section 8.1.1. This model was used to discuss three policy measures and their implications. It was found that the cases all fit the model, which we took as a positive sign of the validity of the model. Topics and processes that are present in the university can be put into place and into a narrative of what may be happening. Many of the side effects that were observed in the cases were supported by the findings of Studies 1 and 2.

One of the starting points of this research was the fact that DUT had invested a lot in interventions to increase student success, but that none of these measures had led to any visible improvements of student success. An obvious explanation is that the effects were not visible at the level of the cohort: a subgroup of students may have benefitted from these interventions, but the effects dropped out when the data was aggregated at the level of the population. An example is the implementation of the mentor system at applied physics, where some students appreciated the mentor system, while other students did not care for it at all. One size does not fit all: whenever a measure is implemented, some students will appreciate it, others do not. They do not all have the same needs, and the success of a such one-size-fits-all measure needs to affect a critically large mass of students before effects may become visible in graduation rates and it is unlikely for a single variable measure to achieve just that. The mentor systems at other faculties where the mentor groups are embedded in the education organisation tend to be more successful, as the mentor groups become an integral part of the education organisation and fulfil the needs of more students, possibly even the critical number required to start affecting success rates. We observed that the core of the model, the dynamic between education environment, disposition and behaviour, was relatively easy to understand and so were the policies that address this dynamic. Once multiple elements of the model come into play, it becomes more difficult to explain the possible effects of policies using the model. In addition, variables on the periphery of the model, such as aptitude, or elements of the social environment, will have a less predictable effect on the output variable than measures that address the core variables in the model, such as disposition, behaviour and education environment. Even if a measure manages to affect two or all of these elements, effects cannot be guaranteed, as students tend to adjust to measures in such a way that they impede their lifestyles as little as possible. The negative relationship between education environment and study discipline in the model is a sign of this, and so is the role of disposition in the modular education case at Civil Engineering.

Part of the difficulty to predict the outcomes of a measure is due to the fact that each variable has a certain amount of error and leaves large parts of the next variable unexplained, however, it seems that the more embedded an intervention is in the model for student success, the greater the chances that it will create effects. The model is not perfect, as the model did not fit well in the structural equation modelling, and as there was the unexplained relationship between perceptions of education environment and EC Total. We were not able to include the variable of time-on-task due to poor quality of data, but the model is, in its current form, fit to achieve the goal for which is was designed: to understand and design policies to increase DUT student success.

Conclusion 6: *The model for first year engineering student success can and should serve as a tool to design Delft University of Technology policies for increasing student success: policies that address the core of the model are likely to be more successful than policies that address the periphery of the model, however, it is not a predictive model in the quantitative sense.*

Conclusion 7: *the more elements of the model are addressed and incorporated in an intervention, the more likely it is that the intervention will be successful.*

Although the DUT model of student success includes a relatively large number of variables that pertain to a large variety of elements in the university environment, it also excludes many variables that may be meaningful to individual students. Therefore we encourage the people who will use this model to familiarize themselves with the outcomes of the preliminary analyses presented in chapter 7 and in appendices 5, 6 and 7 to get a feel for the more subtle effects of the variables that were not included in the reduced DUT model, but that were included in the preliminary model.

Our model does not explain how students' perceptions or disposition change over time or what it takes to change them, however, we assume that on the individual level perceptions change within and between education terms and on the cohort level. It also changes over the years as teachers and course administrators need at least a year to mitigate issues that came up during the term or year. On the individual level, a single positive or negative experience can change a perception, leading to a change in disposition and behaviour for that student. In Study 4 we learnt that the nitty-gritty of the design and implementation of policies are paramount to their success. In Study 4 case 2 we described the implementation of modular education at Civil Engineering where students were required to sit small tests as a prerequisite to sit the final exam. Many students did not sit the final exam, because they were not eligible based on their scores on the small tests. The small tests were introduced to make sure students kept up with their courses, but in the end it had a detrimental effect on success. This is an important observation for teachers, student counsellors and course administration, because many policy measures may result in such unintended effects. Monitoring is therefore essential, but monitoring on the level of the courses is not sufficient. In this research we learnt a lot by combining information on perceptions of the education environment, students' motivations and situations, by discussing issues on the level of subjects and of the curriculum and by collecting information over time during the first year.

Conclusion 8: *single events and small changes in policies can have large effects on different domains of student success. Therefore evaluation is paramount and cannot be limited to the level of subjects, but should also be extended to the student level and to the course level.*

The most defining choice in this research was the decision to develop a situated and action-oriented model for student success that, as a result of this decision, needed to honour the complexity of the system of student success. This decision made it paramount to include stakeholders in the research and led to the choice of a mixed methods approach to the research. The mixed methods set up proved to be powerful. The two qualitative studies yielded richness in information. It brought out clearly on what topics students agreed with each other, but it also brought out what was particular to individual situations. In purely quantitative studies such outcomes would simply not surface because individual variance tends to disappear when data is aggregated on a higher level, however, the interview studies showed what impact the personal situation of a student can have on her or his student experiences and success. These issues are sometimes played down, but they matter to individual students and policy makers need to remind themselves of the existence and importance of such factors whenever they are working towards increased student success, even if they cannot be fitted in our model.

The quantitative study was enlightening because it distilled the general from the particular by exploring relations between the independent and dependent variables in the preliminary model and leaving out those variables that did not have any significant effects on the level of the full sample. Many of the variables that were included in the preliminary model proved to have small significant effects, with high p-values and small effect sizes. This finding is in line with the above observation of the complexity of the system and it could indicate several things: the model is very complex because there are many variables that have minor influences on the level of the individual student in slightly different variations of gravity, it is also possible that these variables have significant effects for sub samples of the population that do not show on the level of the population, and or it is possible that many of these variables measure the same, or at least similar, latent variables that are not included in the model. Researchers who want to design a model that incorporates the full complexity of student success will find this very difficult to do so for several reasons, discussed below. In a structural equation model a certain number of cases is required for every path or variable that needs to be estimated. When the model contains many different variables, the dataset needs to be very large to support such a model. The number of student records available at a university, however, is far too small to support a linear model with that level of complexity, even if all the students participated in a study to this end. In addition a model of such complexity would be very difficult to understand and work with and even in such a model a lot of the individual variance would disappear. In this research we believe we managed to obtain a subset of variables that captures most of what matters to the first year students in DUT, but this data was skewed and the number of cases was too small. It is likely that the skew will continue to exist in the kind of information we solicited from the students, which would require an even larger dataset to work with if a researcher was to fit a model of the complexity we mentioned.

Researchers who use complex modelling techniques commonly refer to linear models as complicated, because in these models variables and relationships are viewed as static, and as a result they explain less variance than complex models could explain. In this research we used structural equation modelling as a linear modelling technique that takes out the error and residue to give more real estimates of the relationships than, for instance, regression analysis (Byrne, 2010; Hair, Black, Babin, Anderson, & Tatham, 2006; Ullman, 2007). The Bayesian SEM that was performed in Study 3 of this research is based on simulation. Although we were still dealing with a linear model, the Bayesian SEM at least gives a range within which the estimates of the relationships fall in 95 per cent of the simulations, and show that the outcomes are not completely static. The Bayesian paradigm is different from the complexity paradigm, but the notion of simulation and dynamic models is present in both techniques.

Conclusion 9: *it is not possible, nor desirable, to design linear models that capture the full complexity of student success in any university. Additionally, such a model is not informative for understanding and designing policies to increase student success.*

Again this conclusion underlines the importance of the use of mixed methods approaches. As complex linear models can be challenging to work with, it is to be preferred that quantitative models in which the relationships between the variables are clear and understood, are complemented with qualitative information on the particular of the model that helps a researcher to interpret the processes and effects in the model. In this research we used several techniques in the qualitative studies and some of these techniques were more successful than others, but we firmly feel we could not have achieved the same depth in understanding first-year engineering students success in DUT without the combination of qualitative and quantitative methods.

Conclusion 10: *mixed method approaches are extremely informative for research on student success and should be the standard in this line of research.*

9.2 | Recommendations

9.2.1 | Recommendations for DUT

As we observed above, DUT has tried to influence student success by implementing 'one-size-fits-all' measures that often did not address enough critical elements of the model, or did not address these elements in the right way, to have any visible effects on student success. This could partly be attributed to the adjusting properties of students and partly to a lack of knowledge of the needs of the target groups of such interventions, where some target groups avoid contact with a course for reasons that are not completely clear. Most of these interventions have not been evaluated thoroughly, so it is impossible to say if enough of the right things have been done to affect any change. In addition, very little is known about target groups of these interventions. We believe that there may be a lot of fragmented knowledge at DUT; the student counsellors, marketing department and education and student affairs officers will all probably have some ideas regarding where the problems of non-persisters lie. There have been at least two studies done in DUT that, although they have not provided a lot of in-depth information on the subject, at least provided indications of the reasons why students leave (Bos & Versteeg, 2003; Heeringa, 1998). In this research we found that it was very difficult to get in touch with non-persisting students, while this group of students holds the key to obtaining valuable information regarding ways to increase the retention rates. From Study 1 we know that students who are failing tend to withdraw and few people know how they are doing. The outcomes of the survey were skewed towards the successful students. It seems unlikely that the students who are failing respond to requests to participate in course evaluations, and so on. This is a huge problem, not just for this research, because few people know when and for what kind of reasons these students leave exactly, and whether the university could have done anything to prevent these students from leaving. It seems impossible to design policies to regulate departure or to make sure the right students are in the right course if it is unknown who the unsuccessful students are and what drives them, this ties in with the above conclusion regarding one-size-fits-all interventions. We doubt if there is a comprehensive understanding of the issue of non-persistence within DUT as yet there have been no systematic efforts to reach out to non-persisters and to collect information on their experiences. Therefore it is likely that measures taken to aid the students who are failing, are not the kinds of measures that are appreciated by the non-persisting students nor will they address their needs. The implication for this research is that we were only able to make a model that represents successful students, not the unsuccessful ones.

Our most important recommendation for DUT is to start collecting data about the entire student population in a systematic way. In this research we also found that the information we could gather through interviews and the survey had a richness that could not be achieved by regular course evaluations. In the current system used for course evaluations, participation is voluntary and anonymous. It is likely that these questionnaires are probably only filled out by successful students, which leads to a distorted picture of how DUT is valued, as there is only information available of a specific subset of the population. This data cannot be linked to other data sources and therefore it is not useful for the kind of research we believe is essential for DUT if it is to increase student success in a systematic way.

Starting in 2015 all students who register to do a degree at DUT will have to take a test to assess how well their interests and qualities match with what is needed to succeed in the course of their choice. This data will also be available for the non-persisting students. The marketing and communication department is also carrying out research to evaluate its own activities and this information could be linked. There will be many opportunities for DUT to learn more about its students in the future, including those who do not persist. If DUT fails to do this, we believe it will not be able to move away from its ad hoc, and fragmented tradition of policy making.

Recommendation 1: *Delft University of Technology should start collecting and linking data systematically to create a data warehouse and to have access to information on all its students, including the non-persisters, so progress and interventions can be monitored and adjustments can be made in a timely, and rational manner.*

Recommendation 2: *Delft University of Technology needs to collect data at the level of the current course evaluations, but also at the level of the curriculum and of the students to understand issues of student success.*

Recommendation 3: *Delft University of Technology needs to follow up interventions with action-research to monitor the intervention at the level of the students and to complement the quantitative data collection we recommended above with qualitative data to make sure important subtleties at the subgroup or individual levels are not overlooked.*

Small events and unaligned policies have an extensive impact on some students. Acts of kindness, or rudeness, by staff may be game changers for some students. Teachers, technical support staff, student mentors, student counsellors and course administrators need to be thoroughly aware of this, as their impact on a student is often larger than they may think. The same goes for how the education is organised: the way current curricula are set up is not motivating for a proportion of the student population, or those teaching a specific curriculum, although this is outside the scope of this research. Students do not find their courses engaging, and they have few opportunities to learn for understanding. Many students quickly get into a sink or swim mode to survive their courses. The way students are enticed to prioritize their time and efforts is often based on what is in it for them: partial exams may generate credits, but will inevitably displace working on other course work that is given a lower priority. The BSA works in a similar way: students will need to learn to work efficiently towards obtaining as many credits as possible, and students who cannot pick up the pace quickly enough, are seen as unfit for engineering and as failures early on. This only increases the competition, the 'weed out' tradition in engineering and the attribution of failure to the students, rather than seeing the 'failure', partly, as an attribute of the learning environment.

Recommendation 4: *teachers, student counsellors and administrative staff and others coming into contact with students in the education environment need to be aware of the pedagogical implications and impact of their behaviour, the way courses and curricula are organised, and aware of any interventions that are implemented.*

From the discussion of the conditions for an effective BSA, it was clear that high quality assessments and student support are essential. These issues have not been addressed systematically with the inception of the BSA. In this research students commented a lot on the low quality of the assessment and, especially the non-persisters who need student support most, were negative about the kind of support they received. With the rise of the threshold of the BSA to 45 credits, these issues seem more urgent than before.

Recommendation 5: *Delft University of Technology needs to make larger efforts to increase the quality of the course assessments and of its student support, it is essential that the student counsellors expand their efforts, having more time per student, and by developing more systematic ways of serving the students, especially those with special needs.*

Most of DUT's efforts to increase student success have been financed using short term on off limited grants and the interventions or projects were usually terminated when the money ran out, not when the results were attained. This has made it very difficult to make any lasting changes in the education environment and to experiment with conditions to determine which projects did, or did not, have an effect. A final recommendation for DUT therefore is to designate ring fenced funds for long-term efforts to promote and understand student success so that a portfolio of evidence-based interventions can be created. We argued that STEM and non-STEM education settings are very different and if DUT is interested in a more rational and evidence-based approach to improving its education environment, the university cannot sit and wait until other universities have a number of interventions worked out that worked for them, it must be prepared to invest long term to improve its future standing and student success rates.

Recommendation 6: *Delft University of Technology needs to make funds available for long-term efforts that are documented and evaluated to create evidence-based interventions which can be proven to be effective, rather than relying on short term one of limited grants to make improvements.*

9.2.2 | Recommendations for future research

We concluded above that the DUT model of first year student success produced for this research is not perfect: it could not be fitted well to the data, the data on time-on-task could not be included due to low data quality, there were unexplained variances and covariances in the model, and the model was not tested for relevant subgroups, such as male and female students or the DUT boxes. To improve the strength of the model as a tool for policy design, these aspects of the model require further attention. To that end, we recommend that the questionnaire presented in Appendix 4 is refined and used to collect data on first year students to improve our understanding of what promotes DUT first year student success. Part of that is to explore the substructures of the model. Currently we do not have a full understanding of how the substructures in the model, such as education environment, are interrelated. A deeper understanding of how these elements interact will aid in understanding policy and praxis in these areas.

Recommendation 7: *the questionnaire and the model need to be further refined to increase its ability to support our understanding of first year student success. Substructures of the model need to be refined and explored for a better understanding of how the elements of these substructures are interrelated.*

In this research the number of credits students obtained in their first year was used as the output variable in the model. We believe it would be most interesting if other output variables would be used in the model, such as the number of credits obtained in the first term or semester to explore if the proportions of the effects of the variables included in the model change over time. It is possible that early in the academic year certain elements of the education environment play a more important role compared to halfway the second semester. Additionally, it would be interesting to use different output variables, such as the proportion of credits obtained compared to the nominal number of credits students could obtain in a term, grade point average, etc.

Recommendation 8: *the model should be tested further using other output variables.*

A phrase that is often used in our research, is Tinto's: failure is not a lack of success and failure and success need to be treated as separate issues by researchers (Tinto, 1987, 2012). In this research we have not been able to verify this statement, but we believe the research provides support that it is important to treat these issues as related but separate.

Recommendation 9: *student persistence and non-persistence are related but separate issues and need to be treated as such in research on student success.*

We concluded mixed methods approaches should be the standard for studying success and lack thereof in higher education. Studies based on either qualitative or quantitative methods are unlikely to yield the kind and depth of information that was achieved in this study. Researchers need to integrate the methods so they reinforce each other.

Recommendation 10: *research into student success or failure should be done using mixed methods approaches.*

Most of the studies in the field of student success are based on descriptive or longitudinal models that do not have an explicit action-perspective. This is one of the reasons postulated by Tinto (2012) for why earlier research has hardly impacted practice in terms of visible, increased student success. In this research we developed a situated and action-oriented model for student success where the relationships between the variables in the model may not be completely clear, but at least are not hypothetical. These relations exist in practice and have been identified by the students themselves. The model was found to be valuable for assessing a number of policy measures that were intended to increase student success. We believe that other researchers should start making similar efforts and create models that are designed for, and intended to be used by, policy makers.

Recommendation 11: *models for student success or failure need to be action-oriented and need to be designed with the user in mind.*

This recommendation brings us to the observation that many of the studies done in this field have relied on linear statistical techniques, which lead to models that do not incorporate interaction terms between the variables. Cragg (2009) and other researchers deliberately modelled interaction terms and found that the outcomes of the research were very different from research where no interaction was taken into account. Cragg also found considerable differences for subgroups of students in her study.

Although we designed a fairly complex linear model, incorporating some interactions between variables, we recognise that student success is difficult to describe in linear models as many of the variables in the model interact. We observed in the interviews and in the preliminary analyses that many variables had some kind of relationship, although these did not surface in the SEM. Increasingly researchers call for (Stephens & Richey, 2011) and explore the use of complex models (Davis & Sumara, 2006; Forsman, Linder, et al., 2014; Fraser, Moll, Linder, & Forsman, 2011) and or simulation (Schellekens, Paas, Verbraeck, & van Merriënboer, 2009) in education research. It is useful to view student success as an emerging phenomenon, meaning that many variables are related and as one variable changes, it may affect the entire model. Changes in a variable may have different effects in every run of the model. In other words, everything in a model can be affected by everything else. This redefines education policy making and education research, as there remain very few knowns and the idea of single variable one-size-fits-all simplicity does not sit well with complex models. Recently there have been papers published where these issues with complex models are explored and the results are promising. Forsman, Mann, Linder and Van den Bogaard (2014), for instance, simulated how large the range of changes in the output variable could be if a single variable could be affected or if a cluster of variables could be affected. Although complexity modelling in education is relatively new, we believe that this line of research present a very promising way to learn more about student success.

Recommendation 12: *researchers at student success need to move beyond simplistic linear modelling techniques and explore other methods that allow the incorporation of real life interaction and complexity, such as complexity modelling.*

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Samenvatting

Lage rendementen zijn al jaren een hardnekkig probleem bij de TU Delft. Veel studenten vallen uit tijdens hun studie en de studenten die blijven, doen vaak aanzienlijk langer over hun studie dan de nominale studieduur. Enige uitval in het eerste jaar wordt in het algemeen niet als een probleem opgevat, de propedeuse is immers bedoeld voor oriëntatie, selectie, en verwijzing. Uitval in latere jaren heeft vergaande gevolgen. Veel van de late uitvallers hebben moeite alsnog elders een opleiding succesvol af te ronden, maar zij hebben dan wel een studieschuld waar geen diploma tegenover staat. Voor de maatschappij leidt deze vorm van uitval dan ook tot een grote kostenpost. Uitvalpercentages bij de TU Delft liggen in het eerste jaar tussen de 20 en 50 procent en gemiddeld komt zo'n 60 procent bij de eindstreep van het master diploma. Deze percentages zijn vergelijkbaar met de uitvalpercentages van andere technische universiteiten in Nederland en in bijvoorbeeld de Verenigde Staten. De percentages bij alfa -, gamma - en natuurwetenschappen liggen iets lager, maar de verschillen lijken betrekkelijk marginaal. Bij de ingenieursopleidingen in het bijzonder worden dergelijke uitvalpercentages als problematisch ervaren omdat er op de arbeidsmarkt een groot tekort aan mensen met een bèta-technisch profiel wordt geconstateerd.

De TU Delft kampt al enige tijd met dit probleem en heeft veel geïnvesteerd in mogelijke oplossingen en interventies. Dit heeft echter niet tot zichtbare verbeteringen in de rendementen geleid en het is niet duidelijk hoe dit komt. De interventies zijn zelden gedocumenteerd of geëvalueerd. Bij de projectbeschrijvingen en –evaluaties die wel beschikbaar zijn, lijkt het erop dat deze projecten opgezet en uitgevoerd waren volgens de toen beschikbare inzichten uit wetenschappelijk onderzoek en met eenmalige subsudies werden gefinancierd.

Er is veel onderzoek uitgevoerd naar studiesucces. Veel van het onderzoek is gebaseerd op descriptieve modellen, waarbij de relaties tussen de variabelen onduidelijk zijn en op cross-sectie data die zeer gevoelig zijn voor fluctuaties en daarmee voor meetfouten. Onderzoek heeft wel veel inzichten opgeleverd over, onder andere, welke variabelen er toe doen als het gaat over studiesucces. Tevens is het duidelijk geworden dat veruit het grootste deel van de verklaarde variantie in studiesucces te herleiden is tot student-gebonden factoren. Deze onderzoeken hebben in de praktijk echter zelden geleid tot een verbetering in rendementen. Tinto (2012) heeft postuleerd dat dit deels komt door het feit dat veel van het onderzoek is ingegeven vanuit abstracte en theoretische inzichten, zonder dat er van te voren goed is nagedacht over hoe zinvol de uitkomsten zijn voor het onderwijsveld.

Het doel van dit onderzoek was een model voor eerstejaarsstudiesucces te ontwikkelen met een handelingsperspectief, oftewel een model specifiek bedoeld voor beleidsmakers om tot inzichten te komen of, hoe en in welke mate een universiteit het studiesucces van studenten kan beïnvloeden. Daarbij is gekozen om het model specifiek te richten op de situatie van de TU Delft, omdat uit de literatuur bleek dat de context met betrekking tot studiesucces in elke universiteit subtiel, doch in belangrijke mate, van elkaar verschilt en omdat het ingenieursonderwijs een aparte tak van sport is gezien het afwijkende opleidingsdoel.

Er is gekozen het onderzoek te beperken tot het eerste jaar. De groep eerstejaarsstudenten is betrekkelijk homogeen, hetgeen het onderzoek versimpelt. Daarnaast geldt succes in het eerste jaar als een goede voorspeller van studiesucces in latere jaren van de opleiding.

Vanwege de keuze voor een situationeel model, werd het betrekken van studenten bij dit onderzoek van groot belang geacht. Het doel was om uit te vinden welke relaties uit dit model golden voor de hele populatie, zodat er een onderscheid gemaakt kon worden tussen relaties die generiek waren voor de populatie van eerstejaarsstudenten en relaties die specifiek waren voor kleinere groepen studenten of individuele studenten. Een laatste stap in het onderzoek was het ontwikkelde model te toetsen aan de praktijk.

De literatuur over studiesucces heeft veel inzichten opgeleverd voor welke factoren er toe zouden kunnen doen voor studiesucces. Grofweg zijn de factoren op te delen in de volgende clusters: student-gerelateerde variabelen, zoals studentkenmerken en studentdisposities, de sociale omgeving, het onderwijsklimaat in de breedste zin van het woord, de vormgeving en organisatie van het onderwijs, studiegedrag en aan de studie bestede tijd. Er is nog weinig onderzoek gedaan naar studiesucces en –uitval in het hoger technisch onderwijs, maar het is wel duidelijk dat er binnen de ingenieursopleidingen sprake is van een zeer competitieve cultuur, waarbij een opvatting heerst dat het aantal studenten dat het vermogen heeft om een goede ingenieur te worden, beperkt is. Het is ook gebleken dat studenten die uitvallen deels tegen dezelfde problemen aanlopen als de studenten die blijven. De gedeelde problemen hebben te maken met een verlies van interesse, het hoge studietempo, de druk om te presteren, en de manier waarop onderwijs wordt gegeven en georganiseerd. De uitvallers meldden echter meer problemen en hadden vaker problemen met het beroepsperspectief van de opleiding en met opleiding gebonden factoren. Uit de literatuur blijkt ook dat de beslissing te stoppen met de opleiding de uitkomst is van een proces, en zelden tot nooit een ad hoc beslissing is.

De onderzoeksopzet was als volgt. De eerste studie was een kwalitatieve studie met vier mentorgroepen van verschillende opleidingen en werd uitgevoerd in het academisch jaar 2009/2010. Deze opleidingen waren geselecteerd omdat ze in verschillende 'boxen' zitten. De boxen worden bij de TU Delft gebruikt om vergelijkbare faculteiten en opleidingen te clusteren, omdat er wordt erkend dat sommige opleidingen meer gemeen hebben dan andere. In Delft wordt gesproken van een engineering box, een science box en een design box. Gedurende het eerste jaar werd er drie keer gesproken met groepen studenten. De uitvallers werden benaderd voor telefonische interviews. Dit bleek in de praktijk lastig uit te voeren, omdat de uitvallers slechts mondjesmaat reageerden op verzoeken voor een gesprek. De tweede studie was bedoeld de uitkomsten van de eerste studie te valideren en aan te vullen en vond plaats in het academisch jaar 2010/2011. Daartoe is een kwalitatieve studie gedaan met een groter aantal studenten die ook drie keer in kleine groepen zijn geïnterviewd gedurende hun eerste jaar. In deze studie waren er bij drie opleidingen meerdere groepen gerecruteerd en, ter aanvulling, van de andere opleidingen steeds een groep studenten. Deze opleidingen waren bouwkunde, civiele techniek en toegepaste natuurkunde. Wederom is geprobeerd de studenten die tijdens het jaar uitvielen te benaderen voor een telefonisch onderzoek en ook deze keer bleek het erg moeilijk te zijn om in contact te komen met deze personen. Er zijn in totaal zeven uitvallers geïnterviewd. Deze gesprekken waren zeer informatief, omdat deze studenten ervaringen rapporteerden die in de andere gesprekken niet of nauwelijks aan bod waren gekomen. Uit de literatuur was duidelijk geworden dat het gebrek aan succes niet de inverse is van succes en dat deze twee concepten ook apart behandeld zouden moeten worden door onderzoekers en beleidsmakers. Omdat er maar over een zeer beperkte groep uitvallers informatie beschikbaar was, maar de informatie die zij gaven anders van aard was, betekende dit dat het voorliggende project zou moeten draaien om het ontwikkelen van een model voor eerstejaars succes, en niet voor eerstejaars uitval.

De derde studie was van kwantitatieve aard, zodat het model getest en gereduceerd kon worden met behulp van lineaire statistische methoden. De eerste studies hadden bijzonder veel informatie opgeleverd over mogelijke factoren en over de relaties tussen deze factoren. Het model dat op basis van deze informatie geformuleerd werd, is als volgt te beschrijven: succes vormt de outputvariabele van het model en is geoperationaliseerd als het aantal behaalde studiepunten in het eerste jaar. De twee centrale clusters van variabelen zijn gedrag en dispositie. Andere variabelenclusters die een rol spelen, zijn studentpercepties van het onderwijsklimaat, de opleidingskenmerken zoals het aantal college-uren, de sociale omgeving van de student, zoals lidmaatschap van een vereniging, en allerlei studentkenmerken, zoals geslacht, aanleg, opleiding, zittenblijven, sociaal-economische status, reistijd, etc.. Het gedragscluster omvat studiegedrag en daadwerkelijk aan de studie bestede tijd. Dispositie betreft studentgerelateerde kenmerken die veranderlijk zijn over de tijd, zoals prestatiemotivatie en zelfvertrouwen. Effectief gedrag en voldoende bestede tijd leiden tot studievoortgang. Een positieve dispositie leidt tot meer en effectief studiegedrag. De perceptie van het onderwijsklimaat heeft een effect op de dispositie. De sociale omgeving en de studentkenmerken vormen input voor disposities, gedrag en percepties van het onderwijsklimaat.

Om het model te kunnen fitten met data is een enquête opgesteld voor cohort 2009 en 2010 op basis van een analyse van de literatuur en de uitkomsten van studie 1 en 2. De enquêtes zijn uitgezet in oktober 2010: de studenten van cohort 2009 zaten toen net in hun tweede jaar en dat betekende dat de enquête alleen is ingevuld door studenten die het jaar ervoor een positief BSA advies hadden gekregen. De dataset van cohort 2010 werd daarom beschouwd als de sterkere dataset, omdat deze ook de informatie bevatte van de potentiële uitvallers. De uitkomsten van de enquête werden, met toestemming van de respondenten, gekoppeld aan gegevens uit het administratieve systeem met voortgangsgegevens van de TU Delft en aan kenmerken van de studieprogramma's, zoals het aantal uren college, projectgroepen, etc. De enquête bevatte vragen over studentdisposities waarover geen informatie bekend was in de TU database, zoals bijvoorbeeld motivatie en academisch zelfvertrouwen, percepties van het eigen studiegedrag en van het onderwijsklimaat. Het onderwijsklimaat omvatte percepties betreffende docenten, faciliteiten, toetsing en onderwijsorganisatie.

De respons was bescheiden, in beide cohorten lag deze rond de 20 procent. De respons was representatief voor de verhoudingen tussen mannen en vrouwen en voor de opleidingen, maar de respondenten weken significant af van de populatie voor wat betreft het aantal behaalde studiepunten: de respondenten hadden meer punten behaald. Bij de verwerking bleek dat de data niet standaard-normaal verdeeld was. Het plan om het model te verkennen met behulp van maximum likelihood structural equation modelling (SEM) bleek niet haalbaar, vanwege de skew, kurtose en het beperkte aantal datapunten. In plaats daarvan is de SEM uitgevoerd met behulp van Bayesiaanse simulatie. Echter, voordat de simulatie werd uitgevoerd, is de data verkend met behulp van eenvoudigere statistische methoden. Uit deze verkenning bleek dat de gedragfactoren in grote mate correleerden met studievoortgang, oftewel, het aantal behaalde studiepunten. Verder viel op dat veel correlaties matig tot zwak waren, maar wel lage p-waarden hadden. Dit gold voor correlaties tussen alle variabelenclusters. Het was, mede daardoor, lastig om het model te fitten op de data. Het meetmodel voor SEM bevatte drie latente variabelen: percepties van het onderwijsklimaat, dispositie en gedrag. Alle manifeste variabelen die daadwerkelijk gemeten waren als onderliggend aan deze latente variabelen, waren in het meetmodel opgenomen. De Bayesiaanse simulatie liet zien dat de relatie tussen dispositie en gedrag sterk was, maar dat deze relatie een grote spreiding had en niet heel precies geschat kon worden. Er bleek geen directe relatie te zijn tussen gedrag en percepties van onderwijsklimaat, maar de relatie tussen dispositie en percepties van het onderwijsklimaat bleek redelijk sterk. Er was daarmee sprake van een indirect verband tussen percepties van het onderwijsklimaat en het aantal behaalde studiepunten. De variabelen die de sociale omgeving en studentachtergrondkenmerken representeerden, bleken in het model geen effect te hebben. De enige variabele die dat wel had, was de proxy voor aanleg, te weten het VWO eindexamencijfer voor wiskunde. Deze had echter alleen een effect op dispositie, niet op gedrag. De onderwijskenmerken hadden ook geen effect in het model. Saillant detail is dat het model voor cohort 2010 een matige fit gaf, maar dat het model niet gefit kon worden op de data van cohort 2009. In beide gevallen kwam aan het licht dat er een mogelijke directe relatie lag tussen percepties van het onderwijsklimaat en het aantal behaalde studiepunten, maar het is niet duidelijk hoe die relatie eruitziet. Omdat het doel was om een handelingsgericht model te ontwikkelen, hebben we deze relatie niet toegevoegd in het model. Immers, het is onduidelijk wat een dergelijke relatie representeert in de realiteit en hoe deze twee variabelen zich verhouden. Het verdient de aanbeveling om deze relatie nader te onderzoeken, aangezien deze zeer interessant kan zijn voor de TU Delft met het oog op het beïnvloeden van studiesucces. Een andere opvallende uitkomst was dat er een zwakke negatieve relatie bleek te bestaan tussen de percepties van het onderwijsklimaat en de manifeste gedragsvariabele studiediscipline. Deze negatieve relatie was in onderzoek bij de Rijksuniversiteit Groningen al eerder aan het licht gekomen. Hoe positiever het beeld van het onderwijsklimaat bij studenten, hoe lager de studiediscipline. Er is geprobeerd om te achterhalen of de verschillende onderwijskenmerken van de opleidingen ook leidden tot andere uitkomsten in het model. Het bleek niet mogelijk te zijn dit te testen vanwege het kleine aantal datapunten, maar de eenvoudige statistische analyse liet zien dat er op dit punt wel degelijk verschillen lijken te zijn in scores voor gedrag en percepties van het onderwijsklimaat tussen opleidingen.

In studie 4 is het gereduceerde model gebruikt om post hoc een aantal interventies ter bevordering van het studiesucces te analyseren. De interventies die daartoe geselecteerd zijn, waren het bindend studieadvies (BSA), de invoering van modulair onderwijs bij civiele techniek en de invoering van de numerus fixus bij lucht- en ruimtevaarttechniek. Het bleek dat alle elementen van deze interventies correspondeerden met variabelen uit het model en dat de ontwikkelingen die plaatsvonden als gevolg van de interventies, ook te verklaren waren op basis van het model. Zo leek het BSA vooral invloed te hebben op studentdisposities, maar het bleek dat het BSA op niet alle opleidingen direct tot effecten leidde. Dit is te verklaren doordat voor sommige studenten de dispositie sterker werd vanwege het BSA, terwijl voor andere studenten het BSA niet leidde tot een sterkere dispositie. Daarnaast bleek uit de grote spreiding van de padcoëfficiënt tussen dispositie en gedrag dat voor een grote groep studenten een grotere dispositie niet leidt tot effectiever studiegedrag of meer time-on-task. Dit komt overeen met uitkomsten van de interviews.

De invoering van het modulair onderwijs bij civiele techniek betrof de vormgeving van het onderwijs en de toetsing, die in het model vallen onder percepties van het onderwijsklimaat. Het onderwijs werd georganiseerd in kleine, herkenbare units waarbij nooit meer dan twee vakken tegelijk geprogrammeerd waren. De toetsing werd ook anders ingericht: er werd een systeem van tussentoetsen ingevoerd waarbij studenten regelmatig toetsen maakten waarvan het resultaat voorwaardelijk was voor deelname aan het tentamen. Het bleek dat studenten als gevolg van de nieuwe opzet inderdaad meer tijd besteedden aan hun vakken, maar desondanks leidde dit maar tot marginale verbetering van de studieprestaties. Het bleek dat de tussentoetsen die onderdeel waren van de interventie, tot opstoppingen leidden voor de studenten. Daarnaast bleek dat studenten het doel van sneller studeren, dispositie, niet deelden met het opleidingsmanagement. De duidelijkere structuur van het programma leidde tot verminderde studiediscipline en de disposities van de studenten bleven nagenoeg ongewijzigd. Daarmee was het programma wel studeerbaarder, maar leidde het niet tot meer studiesucces.

Tot slot de invoering van de numerus fixus met behulp van centrale loting op basis van het wiskundecijfer, die in het eerste jaar bij lucht- en ruimtevaarttechniek niet leidde tot een vermindering van de uitval. Sterker nog, in het eerste jaar van invoering lag de uitval, ongewijzigd, op 45 procent. Tegelijkertijd was het percentage studenten dat de propedeuse in een jaar haalde, twee keer zo hoog als de jaren ervoor. De verklaring vanuit het model is dat het effect van het wiskundecijfer op het aantal behaalde studiepunten zeer indirect is en daarmee maar een zeer klein effect heeft op de outputvariabele. Tegelijkertijd heeft de numerus fixus bij een aantal studenten waarschijnlijk geleid tot een grotere prestatiemotivatie, wellicht mede als gevolg van een toegenomen commitment aan de opleiding.

Dit onderzoek kent beperkingen. Het model is voornamelijk gericht op studiesucces en het is niet duidelijk hoe dit model zich verhoudt tot studie-uitval. Het verdient de aanbeveling actief data te verzamelen over potentiële uitvallers, zodat dit model getest kan worden op deze groep studenten. Dat is noodzakelijk om effectiever beleid te maken waar deze groep studenten iets aan heeft; studie-uitval is niet omgekeerd evenredig aan studiesucces. Ook is time-on-task niet in het model meegenomen, omdat bleek dat de verzamelde data incompleet was. Het model vertoonde een slechte fit met de data, hetgeen te maken kan hebben met de lage kwaliteit van de data en het beperkte aantal datapunten. Het is niet uit te sluiten dat dit de enige oorzaak was, het is zeker mogelijk dat het model verdere verfijning en verbetering nodig heeft.

We kunnen stellen dat het onderzoek succesvol is geweest in haar opzet: er is een handelingsgericht en situationeel model ontwikkeld voor het eerstejaars studiesucces bij de TU Delft. De relaties tussen de variabelen kunnen geduid worden op basis van de informatie uit de literatuur, maar vooral die uit de interviews. Er is een breed model met een ruime verzameling variabelen die er toe doen voor individuen en groepen studenten in de TU Delft en er is een gereduceerd model waarin alleen algemeen geldende relaties gevat zijn. De opzet van het onderzoek met de combinatie van kwalitatieve en kwantitatieve onderzoeksmethoden heeft goed uitgepakt en we bevelen deze aanpak daarom aan voor iedere onderzoeker en beleidsmaker die meer te weten wil komen over studiesucces in haar of zijn onderwijsinstelling. Samen vormen deze modellen een rijk, informatief en handzaam geheel voor beleidsmakers die interventies en beleid willen ontwerpen ten behoeve van meer studiesucces. Daarbij dient wel opgemerkt te worden dat te verwachten effecten van maatregelen op het aantal te behalen studiepunten beperkt zijn en dat het ontwerpen van effectief beleid niet eenvoudig is. Veel van het beleid betreft maatregelen die gericht zijn op het beïnvloeden van slechts één variabele en de kans dat een dergelijke maatregel effect heeft binnen een complex systeem als studiesucces, is erg klein. Maatregelen zullen meerdere relevante variabelen tegelijk moeten betreffen, wil het leiden tot veranderingen in het systeem en in de outputvariabele studentsucces. Monitoring is daarbij essentieel, omdat het erg lasting is om interactive-effecten tussen de variabelen te kunnen voorspellen. Echter, het onderzoek laat tevens zien dat de universiteit wel degelijk invloed heeft op het aantal studiepunten dat haar studenten behalen.

Summary

Low graduation rates have been a persistent problem at Delft University of Technology (DUT). Many students leave the university without finishing their studies and the students who stay0 graduate after 7 years on average, while the nominal duration of DUT bachelor plus master courses is 5 years. Some level of non-persistence in the first year of the course is generally not considered to be a problem. The goal of the first year of university studies in the Netherlands is to help students orient themselves within their course, to select and to refer students to other options if they decide the course is not for them, either because of the course level or because they lose interest in the course. These students commonly go on to achieve a degree in their new choice of study. Non-persistence in later years is conceived as a problem in the Netherlands, because the students who leave their course well into their second year or later tend to leave higher education without obtaining a degree. These students end up with considerable debts, while the costs for society at large are not compensated for by the higher tax revenues that are associated with university graduates. The first year attrition rates in DUT range from 20 to 50 per cent and on average, 60 per cent of a student cohort will finish their studies at DUT. These attrition rates are comparable to those of other universities of technology in the Netherlands and, for instance, the USA. The attrition rates for arts, humanities, social sciences and natural sciences are marginally lower in the Netherlands. In engineering, however, the attrition rates are considered to be especially problematic because there is a shortage of engineers on the labour market.

Delft University of Technology has been aware of the problem of attrition and study delays and has invested a lot of time and money in possible solutions and interventions. These have not resulted in any visible effects on graduation rates and it is unclear as to why this is the case. The interventions were rarely documented or evaluated. From the documents that are available, it is clear that these projects were, at that time, designed according to the state of the art on a limited budget financed by a limited one off grant. Student success is among the most widely studied topics in education research. Many of these studies, however, describe models in which the relations between the variables are unclear, and that are based on cross-sectional data that is sensitive to fluctuations and measurement error. This body of knowledge does contain, however, a lot of insights into which variables are related to student success. In addition, it is clear that much of the variance in success can be attributed to student-related variables. Outcomes of these studies have usually not led to any improvements in retention rates. Tinto postulated in 2012 that this was, at least partly, due to the fact that much of the research focused on theoretically appealing concepts that were not necessarily meaningful to the people working in education praxis.

Our goal for this research was to develop an action-oriented model on first year student success, specifically designed to support policy makers to design and implement interventions intended to affect student success in a positive way. We chose to focus on the context of DUT, as a review of the literature showed that the context pertaining to student success is subtly different between universities. Engineering education is deemed to be a specific research context, since the aim of an engineering curriculum is to train professional engineers who can design solutions for complex technological.

The research was limited to the first year of engineering education. The group of first year students is reasonable homogenous, which simplifies the research because it reduces the number of intervening variables. In addition, first year student success is a stable predictor of student success in later years of a course.

The decision to design a situated model called for the inclusion of students in the research. It was important to find out which variables were important to success according to the students and how the students perceived the relations between these variables. In addition, we were interested to find out which of these relations held for the larger population and which relations were specific for individual students or groups of students. The final step in the research was to test the model for first year student success in practice.

The literature on student success yielded information on which variables matter to success. These variables can be clustered: there are student-related variables, such as student background characteristics and dispositions, the social environment, the education environment in the broad sense, the attributes and organisation of education, students' study behaviour and time spent on studying. Engineering education is mostly unchartered territory, but from the literature it is clear that engineering is a competitive field with a 'weed out' tradition. This means that many of the staff of engineering courses believe that the aptitude required for engineering is limited to a relatively small number of individuals. It is also clear that students who do not persist deal with issues overlapping with, or similar to, the concerns of students who persist. Shared concerns include loss of motivation, high course load, pressure to achieve, and the way the courses are taught. The non-persisters mentioned more issues and had more trouble with the career perspectives of engineering and with course-related issues. From the literature it is also clear that the decision to leave is not taken overnight, and that it is not the result of a single event, rather it is the outcome of a process of experiencing success or lack thereof in one or more domains of student life.

The research design consisted of four studies. Study 1 was a qualitative study with four groups of first year students from different courses and was done in the academic year of 2009/2010. These courses were selected based on their focus. Within DUT courses are clustered in 'boxes' based on their focus: an engineering box, a science box and a design box.

We felt it was important to include as many possible student perspectives in the research and therefore we wanted to make sure that we included the different perspectives that are recognised within DUT. We organised three group interviews during the year. The non-persisters were asked to participate in telephone interviews, but in practice this turned out to be very difficult as few non-persisters were willing to take part in these interviews. Study 2 was intended to validate and complement the findings of Study 1 and took place in the academic year of 2010/2011. A similar set up was used, but larger numbers of students were included. Again, three group interviews were scheduled during the first year. Three courses, one from each box, were selected and from these courses multiple groups of students were recruited. To complement these groups, we recruited single groups from the other courses. The non-persisting students were invited to participate in telephone interviews, but, again, it proved to be very difficult to get in touch with these persons. In total 7 non-persisters were interviewed. These interviews yielded a lot of information, and these students reported experiences that had not surfaced in the regular interviews. From the literature it was clear that success is not a mirror image of the lack thereof and that persistence and non-persistence should be treated as two separate issues by researchers and policy makers. For the research it meant that the model that was developed could only pertain to student success, as there was too little information available on the non-persisters.

Study 3 was a quantitative study, in which the model resulting from the literature review and Studies 1 and 2 was tested and reduced, using linear statistics. Studies 1 and 2 yielded very rich data on potential factors pertaining to student success and their relations. The model that was based on this information contained the following variable clusters and relationships. The output variable of the model was student progress, which was operationalized as the number of credits students obtain in their first year. The two central clusters of variables were student behaviour and disposition. Student behaviour consisted of study behaviour and time spent on studying. Dispositions consisted of student related variables that were subject to change over time, such as motivation and confidence. Student behaviour fed into the output variable and student disposition, in turn, fed into student behaviour. Another cluster in the model pertained to students' perceptions of the education environment, and this cluster fed into student behaviour and into disposition. The social environment, education and student attributes fed into behaviour, disposition and perceptions of the education environment.

To fit the model with data a questionnaire was designed to collect data from student cohorts 2009 and 2010, based on the analysis of the literature and on Studies 1 and 2. The questionnaire was sent out in October 2010: the students of the 2009 cohort had just started their second year, which meant that these students had received a positive recommendation to continue their studies. In 2009 a new policy intended to increase student success had been implemented: the binding recommendation on continuation of studies (BSA). This measure required that first year students obtained at least half of the first year credits to be allowed to continue their studies in their second year. The dataset on the 2010 cohort was perceived as the stronger dataset of the two, because this dataset contained data on potential non-persisters. The results of the questionnaires were linked to data from the administrative system of DUT, with the permission of the questionnaire participants. Data on course attributes were also coupled with the data. The questionnaire contained items on student attributes about which nothing was known in the central administrative system, on student dispositions, self-rated questions on study behaviour and time spent on studying, and perceptions of the education environment. This included questions on teachers, facilities, examinations and education organisation.

The questionnaire response was relatively small, in both cohorts it was about 20 per cent. The response groups were representative of male and female students ratio and the female and male rations of the courses, however, the students who participated in the questionnaires had obtained significantly more credits than the students in the wider populations. It was found that the data was not normally distributed and that the number of data points was small. The intention to use the statistical technique of structural equation modelling (SEM) based on maximum likelihood estimation was deemed to be unfeasible as a result. Instead, we ran the structural equation modelling using Bayesian simulation. Before we did this, we ran tests using other statistical methods such as correlation analysis and non-parametric tests for significance. From this exploration of the data, it was clear that the behaviour variables explained approximately 50 per cent of the variance and that they showed moderate correlations with progress. The number of correlations that were found was not as large as we had hoped. These correlations in the model were mostly weak to moderate in strength and had very small p-values. This was presumably one of the reasons why it was found to be difficult to fit the model to the data. The measurement model used for SEM consisted of three latent variables: perceptions of the education environment, dispositions and behaviour. All manifest variables that had been measured in the questionnaire, and were taken to underlie the latent variables, were included the model. The Bayesian simulation showed that the relationship between disposition and behaviour was strong, but that this relationship had a large distribution and that is was difficult to give a precise estimate of this relationship. There was no direct relationship between behaviour and perceptions of education environment, but the relationship between disposition and perceptions of the education environment was of moderate strength. This implied that there was an indirect relationship between students' perceptions of the education environment and the number of credits they obtained. The variables that represented the students' social environment and the student attributes, did not have any effects in the model. The only student attribute that did have an effect, was the proxy for attitude: the final grade for maths on the pre-university education exams. This variable only affected disposition, it did not affect behaviour. The education attributes did not show any effects in the model.

A notable detail is that the model for the 2010 cohort had a mediocre fit, while the model could not be fitted on the data of the 2009 cohort. In both cases, however, an undefined relationship between perceptions of the education environment and the number of credits obtained was found. The goal of this research was to develop an action-oriented model and therefore we did not add this relationship to the model, as it was unclear what such a relationship would entail. We recommend continuing to explore this relationship, because it indicates that there is another relationship between these variables that is not mediated through disposition and behaviour and it is a very interesting relation for DUT if it can be manipulated to increase student success. Another interesting outcome was that there was a weak negative relationship between perceptions of education environment and the manifest behaviour variable discipline. Researchers from the University of Groningen have established this negative relation before. The more favourable the perceptions of an education environment, the lower the study discipline. In addition we tried to test for significant differences between students from the DUT boxes, but it was impossible to do so because of the limited number of data points. The exploratory statistical analyses showed that there were significant differences in some scores pertaining to the perceptions of the education environment.

In Study 4 we used this reduced model for first year student success to run a number of post hoc case studies. We selected the binding recommendation on continuation of studies (BSA), the implementation of modular education at civil engineering and the implementation of the numerus clausus at aerospace engineering. It was found that all the elements of these interventions corresponded with variables in the model and that the implications of the interventions could be explained using the model. The BSA mainly influenced student dispositions, but an evaluation of the BSA showed that the measure did not affect all the courses right away. This can be explained by the fact that for some students BSA leads to a stronger disposition, while not doing so for others. The estimate of the path coefficient for the relationship between disposition and behaviour had a large distribution and this means that the effect of an increased score on disposition did not lead to the same increase in effective study behaviours or increased time on task for all students. This is in line with the outcomes of the interviews from Studies 1 and 2. The implementation of modular education at civil engineering affected the organisation of education and the examination scheme; both were included in the cluster on perceptions of education environment. The courses were organised in smaller units and no more than two subjects were offered in the same term. The examinations were redesigned: a system of part exams was implemented and students were expected to take several smaller tests during the term. They were given prompt feedback on their results and good test results were a prerequisite to take part in the final exam. Students spent more time on their studies, however, it was found that many students failed some of the small tests and were barred from the exam. As a result, the student success rates increased only slightly. Student reported in an evaluation that they did not share the administration's goal of progression, which is a factor that pertains to disposition. The course at civil engineering became more do-able, but the students' success did not increase significantly.

The *numerus clausus* entry system at aerospace was set up as a weighted lottery based on a student's final school grades for relevant university preparatory education subjects in 2012. It was expected that by selecting the smartest students the success rates would increase. It has to be noted here that in the first year the *numerus clausus* was implemented, there were fewer enrolments than places, so the lottery itself never took place as all the students who registered for this course were offered a place. The attrition rate for first year aerospace remained unchanged at 45 per cent, while the proportion of students who obtained their first year diploma in one year doubled. The explanation based on the model was that the effect of aptitude on the number of credits students obtain, was small and difficult to predict, as it was mediated through many other variables. The *numerus clausus* lottery seemed to have motivated other students to greater achievements, which could be attributed to an increased commitment to the course as a result of selection.

This research has limitations. The model is aimed at success, so it is not clear how the DUT model is related to non-persistence. We recommend that the university starts to collect data on potential non-persisters and refines the model for this group of students. It should also design more effective policies targeting this specific group based on better data. Knowing how much trouble we had to collect the data on non-persisters and knowing that it is very likely that we only spoke to a specific subset of the non-persisters, we are dubious as to how much collected information there is available on this group within DUT. We therefore have reservations about the effectiveness of measures to date designed for this group as failure is not the mirror image of success. We were not able to incorporate the variable time spent on studying in our model, because the data quality on this variable was very poor. The model fit poorly on the data, but this could be a result of the small number of data points and the low data quality, however, it could also be that the model needs further improvement.

We conclude that the research was successful: we developed an action-oriented and situated model for first year student success at DUT. The relationships in the model can be supported by outcomes of the interviews and to a lesser extent, the literature analysis. The broad model includes variables that matter at the level of individual students and subgroups of the student population. The reduced model contains those relationships that are general for the population of first year students at DUT. Together these models form a rich and informative instrument that is usable for policy makers who design interventions intended to increase student success. The mixed methods approach that was chosen for this research, worked out well and we recommend this approach to any policy maker and researcher who is interested in learning more about the topic of student success at their institutions. We need to point out that the expected effects of any policy intended to increase student success in terms of increase in the number of credits students obtain, will be relatively small, and that it is not easy to design interventions that work. Many interventions are designed to address a single variable and the chance that such a measure will have an effect in a complex system such as student success, is small. Any future interventions need to address multiple relevant variables in the model simultaneously for them to have any effects on the system as a whole, and the number of credits obtained by a student specifically. Monitoring is key as it is very difficult to predict interaction effects of the relevant variables. Our research shows that the university administration of DUT has had an influence on the number of credits that students obtain, but that there is still more that might be done as we gain a better understanding of the complex issues that drive and predicate student success.

Appendix 1 | Timeline of history of legislation in Dutch Tertiary Education between 1945 and 2012

Year	N students in Dutch universities*	Description of legislation
1960	40,700	WWO, Wet op het Wetenschappelijk Onderwijs, Scientific Education Act. This is the first extensive law regarding scientific education since the liberation in 1945. The law was intended to accommodate the growth in student enrolment that resulted from the "baby boom" after the liberation. Public universities became legal entities. Research was included as an assignment for universities. This law did not lead to many and large changes, but it created the beginnings of a closer relationship between the government and the universities.
1971	113,000	WUB, Wet Universitair Bestuur, Governance Reform Act. This law was based on discussions concerning low efficiency of scientific education and an outcry of the student body for more democracy in the universities. This law served as an amendment of the WWO, to experiment with new forms of governance. The law required universities to install participation councils representing students, non-scientific and scientific staff. These councils had decisive powers on the levels of university, school and department. These three levels had separate management boards. Professors were to collaborate within departments, which meant they had to give up some of their independence.
1981	157,000	WTF Wet op de Twee-Fasenstructuur, Two-Phased Structure Act. Student enrolment was still increasing and there was a cry for more efficiency in universities. One of the major goals of this law was to improve the graduation rates. This was achieved by major changes in education logistics that had profound effects on curriculum organisation. Until this law went into effect, all university curricula took 5 years. The WTF shortened this to 4 years for all curricula, including the STEM disciplines, and installed a 'propedeutic exam' after one year. This year served as a year for orientation, selection and referral. After graduation there were postdoctoral curricula available for doctors, teachers and researchers. The goals for university education were unchanged, but policymakers were convinced this law would not lead to a deterioration of quality through more efficient use of resources. Students could be registered in the university for a maximum of 6 years. To create conditions for students to achieve this and for standardisation and harmonisation between curricula, policy makers introduced a normative course load of 1700 clock hours a year.
1985		The polytechnic schools in Delft, Eindhoven, Twente, Tilburg en Wageningen were renamed as universities.
1986	185,900	Wet op horizontale doorstroom HBO WO, Law on horizontal transfer. At this time schools for applied sciences (HBO) were not considered 'higher education'. This law granted access to the first year of university education (WO) based on a propedeutic diploma of a school for applied sciences.
1986		WSF Wet op de Studiefinanciering, Student Finance Act. This law was intended to make student financially independent by granting all fulltime students between 18 and 30 years of age a 'basis' grant. Parents were required to complement this amount. If they were unable, students could apply for an additional grant. This additional grant took the shape of a loan with interest. An important motivation of this law was to increase equality and access to higher education, again
1988	185,400	Harmonisatiewet collegegelden en inschrijvingsduur harmonized policy of universities and schools for applied science. The law limits the maximum registration term to 6 years for both types of education. Students will need to pay a higher contribution. Students are allowed to reenroll after 6 years, but they will have to pay a higher tuition rate.

Year	N students in Dutch universities*	Description of legislation
1992/ 1993	189,700	WHW, Wet op het Hoger Onderwijs en het Wetenschappelijk Onderzoek, Higher Education and Research Act. Universities, schools for applied research, academic hospitals were brought under one law. Institutions received more autonomy, although the government still carried the primary responsibility for financing higher education. The governance within the universities remained unchanged, but there were major changes in the logistical side of education: there were new requirements for enrolment, registration, course load and exams. The normative course load was set to 1680 clock hours per year. 40 hours of study equalled 1 credit, which meant that each curriculum spanned 42 weeks a year. Institutions would be financed based on the number of students in the first year and the number of diplomas awarded. The engineering curricula were expanded to 5 years again. An important reason to do so was because the 4-year curriculum in engineering meant Dutch engineers were undertrained compared to their peers in other European countries.
1993	186,900	Wet op de StudieFinanciering, invoering Tempobeurs, Student Finance Act, amendment to implement the 'Tempo Grant'. In this law students' yearly progress in education is linked to their right to a grant. The grant is issued as a loan, unless students comply with a progress requirement of 10 credits (25% of the total 42 credits) in each year. If students comply, the loan is turned into a gift. Credits did not have to be obtained in the curriculum students registered in. In 1995 the progress requirement was set to 21 credits, 50% of the normative course load to increase student progress. Students were entitled to a Tempo Grant for the normative duration of their curricula plus one year. For engineering this was 5+1=6 years.
1996	166,200	Wet op de StudieFinanciering, invoering Prestatiebeurs, Implementation of the 'Performance Grant'. The conditions for the Performance Grant are similar to those of the Tempo grant: the Grant is a loan unless students comply with a progress requirement. Students need to obtain 29 credits in their first year (70% of the normative load). The grant is awarded for the normative number of years for a curriculum. Students need to graduate in 6 years after first enrolment.
1997	160,700	MUB, Wet Modernisering van de Universitaire Bestuursorganisatie, University Government Modernisation Act. The management level of the departments is terminated, that means that the Schools get more responsibility for the structure of education. The Board of Executives is complemented with a supervisory board. The focus of this change is to enhance efficiency and quality. Students and (non-) scientific staff participate in the decision making process, but their powers are limited compared to the WUB from 1971 which is replaced by this act.
1999	163,000	Wet Indexering Collegegelden, Tuition Indexation Act. From now on tuition would be indexed for inflation on a yearly basis.
2000	166,300	WSF, Wet Studiefinanciering 2000, Student Finance Act 2000. Students will now have 10 years instead of 6 to graduate for their loans to be turned into gifts.
2003	189,500	Aanpassingswet Invoering Bachelor- en Masterstructuur, Amendment Act on implementing Bachelor and Master structure. As a result of the Bologna Declaration universities offer three-year bachelor curricula and one-year master curricula, except the engineering courses: they offer two-year master curricula. The 4-year courses in universities of applied sciences were recognised as bachelor courses. Accreditation will become part of an international system of quality assurance.
2011 until 2012	245,322	Invoering Langstudeerboete, implementation of the 'longterm student penalty'. This penalty consisted of a tuition that was some 3000 euros higher than the normal tuition fee for students who were taking more that the nominal duration plus one year for their course. This penalty was terminated in the year after. Instead of this penalty, policy makers started discussing the foundations of the entire student finance act that is based on loans alone.
2012	NA	Addition to the WHW, the bachelor-before-master rule was implemented for all courses in the Netherlands. Students without a bachelor diploma were no longer allowed to sit course exams for master courses.

* Student numbers were retieved from Centraal Bureau voor de Statistiek (2014).

Appendix 2 | Interview guides and stimulus objects

A2.1 | Interview guides for student cohort 2009

A2.1.1 | Interview guide for first round of group interviews in September/ October 2009

Goal of the group interviews: create an image of perceptions students have of their course, success and BSA.

Choice of academic field

1. What factors influenced your choice of academic field? Write every factor on a separate sticky note.
   Stick the notes to the sheet of paper on the wall: centre represents "Much influence", the outer rings represent "Moderate influence".
2. Which other fields/courses did you consider?
3. Did you visit the TU Delft campus prior to enrolling? Did you participate in 'Student for a Day"? Did you join a student association?
4. What do you like about this course?

Impressions

5. You have been here two weeks. Can you describe the impressions you have of the course so far briefly?
   a. What is your impression of the curriculum, the teachers, and how you are taught?
   b. What are your impressions of the level of the course and the required pace of study?
6. What do you worry about in this course?
7. Are you aware of the BSA? How do you feel about it?

Success

8. What would you like to achieve in this course?
9. What would you like to have achieved after three years of study?
10. What would you like to have achieved at the end of this year?
11. What do you think are the odds of graduating in three years?

A2.1.2 | Interview guide for second round of interviews in February/ March 2010

For Applied Physics and SEPAM this was the first interview, because it proved to be impossible to meet earlier in the year.

Why did you choose for this course? Would you make the same choice now?

Expectations, and do they come true?

1. How much time do you devote to your studies? (lectures, homework, projects, etc.)
   a. Is that the same amount as in UPE?
   b. Is it more or less than you expected at the beginning of the year? Is it more or less than what you intended at the beginning of the year?
   c. Can you explain why that is the case?
2. How do you feel about the levels of the exams?
3. Interaction with the teacher. Do you have a lot of interaction with your teachers? Is that less or more than you expected?

To continue or to stop?

4. Are you aware of any students who have left?
   a. Have you considered stopping with this course yourself? When? Why did you decide to persist?

Social environment

5. How is the atmosphere in your mentor group? Do you experience support from these people or do you just meet them in the context of the group? Do you have friends in the course? With whom do you talk about your studies? Do you think this might be different for students who live with their parents and students who live independently?
6. Would you recommend this course to others right now? Why or why not?

BSA

7. Have you received your preliminary BSA advice? Did you see it coming or did it catch you by surprise? How do you plan to move on?
8. Is there anything that needs to change next semester for you to be successful if any?
   a. Your pace of study
   b. How you spend your time
   c. The curriculum

For Mechanical and Aerospace Engineering this was the second interview.

To make a storyline with the students:

What were your highs and lows in the past semester? What happened? Why did it influence your experience the way it did?

A2.1.3 | Interview guide for third round of interviews May/ June 2010

This interview consists of two separate parts. First we do a brief storyline dialogue and second we identify factors that pertain to student success.

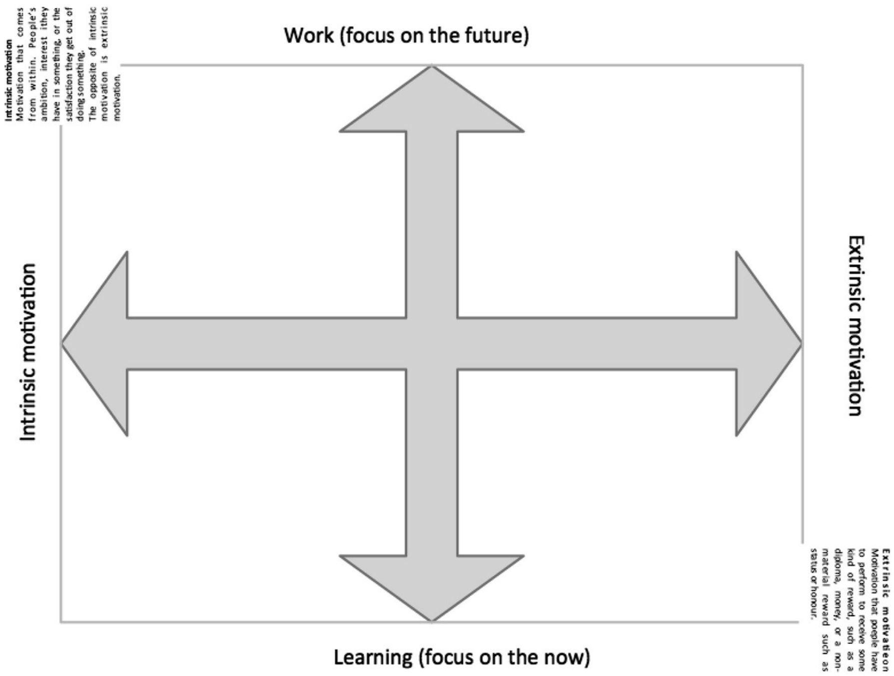
Story line: How did you experience this past semester? What were the highs and lows and to what experiences are they related? Did the BSA play any role in this?

Factor identification: Write down all the possible factors/variables that contribute to obtaining credits. Which ones apply to you? Write down all the possible factors/variables that obstruct obtaining credits Which ones apply to you?

Stick the notes on a sheet of paper. Try to cluster your sticky notes with those of other students if they seem to refer to similar constructs. If you believe factors are important, stick them in the centre of the sheet. If you believe factors are not quite so important, stick them further away from the centre.

A2.2 | Interview guides for student cohort 2010

A2.2.1 | Stimulus objects for the first round of group interviews September 2010



Social networks

- In which social networks do you participate?
- How important are they to you? What do these networks mean to you?

Network	-/-	-	+/-	+	+/+
Sports association					
Fraternity or other student association					
Study association					
Course – peers and friends					
Home – contacts with flatmates in Delft					
Home – contacts with family and friends from outside university					
Work – contacts with colleagues					
Other, namely					

Put your name in the boxes that apply to you.

Subject 1, 2, 3

- **What do you think about this subject?**

Positive	Negative

- **What do you think about the teacher?**

Positive	Negative

- **What do you think is expected of you in this subject? Why do you think that?**

- **How do you prepare for this subject? How much time do you spend on it?**

The course to date

- **What do you think about the course to date?**

Positive	Negative

- **What do you think of the faculty/university?**

Positive	Negative

- **What do you think is expected of you in this course? What do you need to do to be successful in this course? How can you tell?**

- **How much time do you spend on your course? Are you intending to obtain P-in-1? How do you estimate your chances for success? Why?**

A2.2.2 | Interview guide for the second round of interviews February/ March 2011

As you may or may not remember, I am working on research on the extent to which study success scan be influenced. With all the discussion on the long-term student penalty, this is back on the agenda. We have an hour to talk to each other about your experiences of this semester and how you have been during that time. This is a group interview, so feel free to respond to each other and to ask questions. Studying is not always easy and I am interested in hearing about the good and the bad. I hope we will touch on both, but that implies that everything that is said here today is not to be shared with others outside this group.

Question 1: How would you describe your experiences of last semester at DUT?
Is there anything that stood out? How did you feel about it?
Question 2: What were the most important events last semester?
Write them on a sticky note and put them on the storyline.
What happened and who were involved?
Question 3: Have you considered to quit at some point?
What happened?
Why did you decide to stay?
Do you know others who stopped or who contemplated to stop?
Do you know what happened with them?
Question 4: What are your goals for this semester? Are you planning to do things differently from last semester?

A2.2.3 | Stimulus objects used in the workshop for modelling success May/June 2011

Student/ social environment/ education environment
- Individual brainstorm

Name and course:

- **Which variables, events, situations, aspects, etc in the learning environment have had a positive/negative effect on student success. Try to be as concrete as possible, give examples.**

1. -
2. -
3. -
4. -
5. -

Student/ social environment/ education environment - Group ranking

- Compare your results with those of someone else, select three positive/negative variables and make a shared top 3. Please explain why you choose these three.
- 1
- 2
- 3

Student/ social environment/ education environment - Group ranking

Positive	Negative
• 1	• 1
• 2	• 2
• 3	• 3

A2.3 | Interview guide for non-persisters

This interview guide was used in Study 1 that was reported in chapter 5 and in Study 2 that was reported in chapter 6.

Introduction:
My research is on student success and the effects of measures designed to increase success, such as the BSA. Again, all information is treated confidentially.

The choice to stop with a course is not taken overnight. Often there are multiple reasons to stop, and some may be more important than others. I would like to talk about how you reflect on your time in the course and what considerations played a role in your decisions to stop?

1. Can you briefly describe your experience in DUT? How do you feel about it now? What things did you notice when you were at DUT?
2. Which considerations played a role in your decisions to stop? These considerations could have to with academics, social or external factors.
3. What is your next step?
4. Are you aware of the services of the Career Centre that are still open to you?

Thank you for this conversation and I wish you the best for your future.

A2.4 | Consent form

This consent form was used in Study 1 that was reported in chapter 5 and in Study 2 that was reported in chapter 6.

Datum 6 september 2009
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Beste student,

Bedankt voor je interesse in dit onderzoek naar Studiesucces en Rendement op de TU Delft. Dit onderzoek wordt gedaan door ondergetekende in samenwerking met Afdeling Onderwijs en Studentzaken en de faculteit Techniek, Bestuur en Management. Het onderzoek gaat over de vraag of en hoe we de doorstroom in het onderwijs op de TU Delft zouden kunnen beïnvloeden en waar mogelijk verbeteren. In deze brief wil ik je meer uitleggen over het onderzoek en over de rol van de focusgroepen waar ik je voor benader.

Over het onderzoek
Studenten in Nederland studeren gemiddeld langer dan de nominale cursusduur. Hier zijn allerlei redenen voor aan te wijzen, zoals studenten die kiezen om bij te verdienen naast de studie, commissiewerk te doen, meer tijd te nemen voor bijvakken, et cetera. Soms lopen studenten ook vertraging op vanwege het niet halen van tentamens of door andere studiegerelateerde problemen. Onderzoekers hebben al vaak geprobeerd om studievertraging en -uitval te verklaren vanuit het analyseren van doorstroomgegevens. Dit heeft veel inzicht gegeven in welke factoren van invloed zijn op vertraging en uitval. We hebben echter deze problematiek nog zelden onderzocht vanuit het perspectief van de studenten zelf.

TU Delft is in collegejaar 2009/2010 begonnen met de invoering van het Bindend Studieadvies (BSA). Dit betekent dat eerstejaars studenten die minder dan 30 studiepunten halen, zich in het volgende studiejaar niet mogen inschrijven voor dezelfde opleiding. De bedoeling van deze maatregel is dat studenten die twijfelen over hun studiekeuze of over hun intellectuele vermogens, sneller uitvallen. Dat zou de doorstroom in het totale programma moeten bevorderen.

Over de focusgroep
In het kader van mijn onderzoek naar door- en uitstroom aan de TU Delft, ben ik benieuwd naar de perceptie van studenten van hun opleiding en van het BSA. Ik ben ook geïnteresseerd in de gevolgen van het BSA voor het studieverloop en in de vraag of de studentpercepties van de opleiding veranderen gedurende de studie en zoja, hoe dat precies verschuift. In totaal zijn er vier focusgroepen van vier verschillende faculteiten. De studenten in deze focusgroepen worden gevraagd om gedurende de eerste drie jaar van hun opleiding twee, of maximaal drie keer mee te doen aan een focusgroepbijeenkomst over dit onderwerp. Deze bijeenkomsten worden van te voren aangekondigd en vinden plaats tijdens een (verzorgde) lunch.

Datum 6 september 2009
Pag./van 2/3

Wat er van je verwacht wordt
Als je mee wil doen met het onderzoek, dan verwacht ik dat je bij deze bijeenkomsten aanwezig zal zijn. Als je verhinderd bent, dan laat je me dit van te voren even weten. Als je besluit je studie bij de TU Delft te beëindigen, dan mag de onderzoeker nog een keer contact opnemen met de student om te spreken over de redenen voor het beëindigen van de opleiding.

Privacy
Om de bijeenkomsten goed te kunnen voorbereiden, heb ik een paar gegevens nodig van je, zoals je telefoonnummer, je e-mailadres. Daarnaast vraag ik een aantal persoonlijke achtergrondgegevens, zoals je geboortedatum en je VWO profiel. De gesprekken tijdens de bijeenkomsten kunnen worden opgenomen. Ik ga vertrouwelijk om met alle informatie die je mij verstrekt. Bij rapportage van uitkomsten in het kader van onderzoek worden alle gegevens zodanig gepresenteerd dat niets te herleiden is tot een persoon.

Deelname aan het onderzoek is geheel vrijwillig. Door in te stemmen met het onderzoek, verplicht je jezelf om gedurende een jaar beschikbaar te zijn voor aan beperkt aantal bijeenkomsten. Er staat in principe geen beloning tegenover je deelname. Ik zorg wel bij elke bijeenkomst voor een verzorgde lunch en daarnaast kun je bijdragen aan wetenschappelijk onderzoek en bijdragen aan (nog) beter onderwijs aan de TU Delft. Denk goed na of je mee wil doen of niet.

Informed consent
Ik heb in deze brief de bedoeling van het onderzoek uitgelegd. Als je bereid bent om mee te doen met het onderzoek, wil ik je vragen om het formulier op de volgende pagina in te vullen en in te leveren bij mij. Daarmee geef je aan dat je deze brief zorgvuldig gelezen hebt en dat je je committeert aan deelname aan de focusgroepen. Deze brief kun je bewaren voor je eigen referentie.

Ik ben gedurende de looptijd van het onderzoek beschikbaar om je vragen over dit onderzoek en je deelname te beantwoorden.

Hartelijk dank,

Met vriendelijke groeten,

drs Maartje van den Bogaard
m.e.d.vandenbogaard@tudelft.nl
015-2783768
06-42170195

Datum 6 september 2009
Pag./van 3/3

TUDelft

Verklaring van deelname

Ik, ………………………………………………………… verklaar door ondertekening dat ik gedurende het komende collegejaar beschikbaar ben om deel te nemen aan het onderzoek naar percepties van de opleiding aan de TU Delft en BSA.

Mijn contactgegevens zijn
Emailadres:
Telefoonnummer:
Studienummer*:
Geboortedatum:
VWO profiel:
Eindexamencijfer natuurkunde:
Is dit je eerste opleiding in het hoger onderwijs? Ja/nee
Zo nee, welke opleidingen heb je hiervoor gedaan en wanneer ben je daarmee gestart?

Ik verklaar dat als mijn contactgegevens wijzigen, ik dit doorgeef aan de onderzoeker.

Plaats, datum, handtekening.

*Studienummer wordt binnen dit onderzoek alleen gebruikt om de deelnemer binnen dit onderzoek te identificeren. Er wordt geen verbinding gelegd met andere bronnen van informatie over de student.

Appendix 3 | Shortlist, definitions, operationalizations and rationale for variables

Table A3.1 | Shortlist, definitions, operationalization and rationale for variables

Shortlisted variables	Rationale	Description of operationalisation	Operationalisation	Rationale for inclusion of variables
Student attributes				
Age	Students age	Age on first day of the first academic year of enrolment	Age	Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Prins, 1997; Van den Berg & Hofman, 2005; Van der Hulst & Jansen, 2002.
Gender	Students gender		Gender	Araque et al., 2009; Beekhoven et al., 2002, 2003; Felder et al., 1994; French et al., 2005; Georg, 2009; Jansen & Bruinsma, 2005; Moller-Wong & Eide, 1997; Van den Berg & Hofman, 2005; Vogt, 2008; Zhang et al., 2004.
Aptitude	Students aptitude	Secondary Education grades for Maths and Physics	SE Maths SE Physics	Beekhoven et al., 2002, 2003, 2004; Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Moller-Wong & Eide, 1997; Oseguera & Rhee, 2009; Prins, 1997; Van der Hulst & Jansen, 2002; Veenstra et al., 2008; Zhang et al., 2004.
Course	Students course	Bachelor course	BSc course BSc box	Becher, 1994; Lattuca et al., 2010; Smart, 2010; Studies 1 and 2.
Prior education	Students can enroll based on different training	Secondary Education profile or other prior education	Prior Ed	Moller-Wong & Eide, 1997; Prins, 1997; John C. Smart, 2010; Warps et al., 2010.
Academic skills	General academic skills that underlie student success	Self assessed language skills, in Dutch and English.	Lang Dutch Lang English	Besterfield-Sacre et al., 1997; Burtner, 2005; Jansen & Bruinsma, 2005; Moller-Wong & Eide, 1997; Van der Hulst & Jansen, 2002; Warps et al., 2010; Zhang et al., 2004.
	General academic skills specific for engineering student success	Skills in Maths, Physics and working with computers	Skills Maths Skills Physics Skills Comp	Besterfield-Sacre et al., 1997; Burtner, 2005; Jansen & Bruinsma, 2005; Prins, 1997; Veenstra et al., 2008; Vogt, 2008; Warps et al., 2010.
Commute time		Commute to campus per week in hours	Commute time	Bean, 1982b; Beekhoven et al., 2004; Studies 1 and 2.
Socio economic status, first generation of students		Education level of parents	Ed Parents	Araque et al., 2009; Beekhoven et al., 2002; Beekhoven, 2003; Bruinsma & Jansen, 2007; Crul & Wolff, 2002; Felder et al., 1998, 1993, 1994; Firmino da Costa & Teixeira Lopes, 2011; Georg, 2009; Oseguera & Rhee, 2009; Van den Berg & Hofman, 2005; Warps et al., 2010.

Shortlisted variables	Rationale	Description of operationalisation	Operationalisation	Rationale for inclusion of variables
Student attributes				
Orientation to science and engineering		Scores on Beta-mentality model	Science orientation	Alpay, Ahearn, Graham, & Bull, 2008; Besterfield-Sacre et al., 1997; Burtner, 2005; Felder et al., 1993; Warps et al., 2010; Woodcock, Graziano, Branch, Ngambeki, & Evangelou, 2012.
Choice of course/ field	Indicator of how well students prepared themselves for their choice of study	Number of PR related activities students participated in	PR total	French et al. 2005; Warps et al. 2010.
Impairments and learning disabilities		Number of self-reported impairments	Imp total	Beekhoven et al., 2004; Warps et al., 2010; Study 2.
Social environment				
Student social life	Student engagement in social environment	Membership of any fraternity, sports or cultural association	Membership frat, etc. Membership total	Berger & Milem, 1999; Technische Hogeschool Delft, 1959; Prins, 1997; Warps et al., 2010; Studies 1 and 2.
Housing situation	Housing situation	Housing situation	Housing sit	Beekhoven et al., 2004; Oseguera & Rhee, 2009; Warps et al., 2010; Studies 1 and 2.
Student dispositions				
Expectations	Students who have the right expectancies regarding their course, are better prepared to be successful	Expectancy regarding difficulty of the course	Expec Diff	Beekhoven et al., 2002, 2003; Jansen & Bruinsma, 2005; Need & De Jong, 2001; Warps et al., 2010.
		Expectancy regarding how interesting students find their course	Expec Int	Beekhoven et al., 2002; Need & De Jong, 2001; Thomas, 2000; Warps et al., 2010.
Academic confidence	The extent to which students feel confident on achieving short-term success	Expectancy regarding obtaining a positive BSA	Expec BSA	Beekhoven et al., 2002; Cabrera et al., 1992; Thomas, 2000; Prins, 1997.
Commitment	Importance students assign to obtaining a goal	Institutional commitment: importance of obtaining a degree in Delft	Imp Delft	Beekhoven et al., 2002, 2003; Cabrera et al., 1992; Thomas, 2000; Prins, 1997; Tinto, 1987; Warps et al. 2010.
		Academic commitment: importance of obtaining P-in-1	Imp P	Beekhoven et al., 2002; Need & De Jong, 2001; Prins 1997; Thomas, 2000; Warps et al., 2010.

Shortlisted variables	Rationale	Description of operationalisation	Operationalisation	Rationale for inclusion of variables
Student dispositions				
Motivation	Motivation pertaining to course, DUT and future employment	Importance students assign to elements of the course, DUT, and future employment. If something matters to students, that will be a source of motivation	Course prior Course now Course aft Delft prior Delft now Delft aft Job prior Job now Job aft	Cabrera et al., 1992; Prins, 1997; Seymour & Hewitt, 1997; Veenstra et al., 2010.
Perceptions of education environment				
Teacher	The ability of teachers to get the message across	Teacher has sufficient content knowledge	TC Content	Beekhoven et al., 2002; Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Prins, 1997.
	The ability of teachers to explain topics in different ways	Teachers can explain concepts in different ways	TC Explain	Beekhoven et al., 2002; Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Prins, 1997; Warps et al., 2010.
	Availability of teacher during class	Teachers take time to answers questions from students in the lecture hall	TC Hall	Beekhoven et al., 2002; Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Need & De Jong, 2001; Prins, 1997.
	The teachers are perceived to be experts in their fields	Teachers have truly mastered the subjects they teach	TC Master	Beekhoven et al., 2002; Bruinsma & Jansen, 2007; Prins, 1997.
	Availability of teachers	Teachers are available when students have questions.	TC Available	Beekhoven et al., 2002; Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Need & De Jong, 2001; Prins, 1997; Vogt, 2008; Warps et al., 2010.
	The extent teachers are perceived to be empathic	Teachers can empathize with the students	TC Emp	Beekhoven et al., 2002; Bruinsma & Jansen, 2007; Need & De Jong, 2001; Prins, 1997; Vogt, 2008; Warps et al., 2010.
	The extent teachers are perceived to be enthusiast	Teachers are enthusiastic about their courses	TC Enth	Beekhoven et al., 2002; Bruinsma & Jansen, 2007; Prins, 1997; Vogt, 2008; Warps et al., 2010.

Shortlisted variables	Rationale	Description of operationalisation	Operationalisation	Rationale for inclusion of variables
Perceptions of education environment				
Assessment: projects	Clarity of expectations on projects	In projects expectations are clear	TS Proj	Warps et al., 2010; Studies 1 and 2.
	Constructiveness feedback	Feedback on project is constructive	TS Constr	Warps et al., 2010; Studies 1 and 2.
	Consistency of feedback	Feedback on project is consistent	TS Consist	Studies 1 and 2.
	Transparency of feedback	Final feedback on project is transparent	TS Trans	Warps et al., 2010; Studies 1 and 2.
Assessment: exams	Clarity of expectations for exams	Expectations are clear	TS Exp	Need & De Jong, 2001; Warps et al., 2010; Studies 1 and 2.
	Constructiveness of feedback on assignments	Feedback on formative tests is constructive	TS Feedback	Warps et al., 2010; Studies 1 and 2.
	Representativeness of level of exam	Level of exams is representative of course level	TS Level	Studies 1 and 2.
	Representativeness of content of exam	Content of exams is representative of course.	TS Repres	Studies 1 and 2.
	Sufficiency of time for exam	Enough time to sit the exam	TS Time	Studies 1 and 2.

Shortlisted variables	Rationale	Description of operationalisation	Operationalisation	Rationale for inclusion of variables
Perceptions of education environment				
Facilities	Student well being in the faculty.	There is a good atmosphere at the faculty	FC Atm	Beekhoven et al., 2002, 2004; Warps et al., 2010; Studies 1 and 2.
	Availability of workspaces in faculty	There are plenty of working spaces to study quietly at the faculty	FC StudyF	Warps et al., 2010; Studies 1 and 2.
	Availability of workspaces on campus	There are plenty of working spaces to study quietly on the campus	FC StudyC	Warps et al., 2010; Studies 1 and 2.
	Availability of space to relax	There is plenty of space to relax at the faculty	FC Relax	Warps et al., 2010; Studies 1 and 2.
	Accessibility of student mentor	Student mentor was accessible	FC Stmen	Beekhoven et al., 2002; Warps et al., 2010; Studies 1 and 2.
	Accessibility of teacher mentor	Teacher mentor was accessible	FC Tcmen	Warps et al., 2010; Studies 1 and 2.
	Accessibility of student support	Study support is accessible	FC Stsup	Beekhoven et al., 2002; Warps et al., 2010; Studies 1 and 2.
Education organisation	Spread of course load over a term	Course load was spread evenly over the term	OO Spead	Jansen & Bruinsma, 2005; Need & De Jong, 2002; Warps et al. 2010; Studies 1 and 2.
	Accessibility of course materials	Materials were difficult to understand	OO Material	Warps et al., 2010; Studies 1 and 2.
	Availability of course materials	Materials were unavailable or available too late	OO Late	Need & De Jong 2001; Warps et al., 2010; Studies 1 and 2.
	Clarity of what materials needed to be studied	It was difficult to find out what books/materials we needed to study	OO Book	Warps et al., 2010; Studies 1 and 2.
	Sufficient feedback	I received insufficient feedback on my work	OO Feedback	Warps et al., 2010; Studies 1 and 2.
	Appeal of courses	The courses of this term did not appeal to me	OO Courses	Warps et al., 2010; Studies 1 and 2.

Shortlisted variables	Rationale	Description of operationalisation	Operationalisation	Rationale for inclusion of variables
Student behaviour				
Study behavior. Operationalized by using SRL framework as reported by Schmitz and Wiese 2006	Pre action phase	Goals	Goal	Carroll, 1963; Schmitz & Wiese, 2006; J. Stolk et al., 2010; Van der Drift & Vos, 1987; Veenstra et al., 2008; Zimmerman & Kitsantas, 2007; Zimmerman, 2000; Studies 1 and 2.
		Motivation	Deepl1, Exam	
		Self efficacy	Tempo	
	Action phase	Metacognitive strategies	Behind	Carroll, 1963; Schmitz & Wiese, 2006; J. Stolk et al., 2010; Van der Drift & Vos, 1987; Veenstra et al., 2008; Zimmerman & Kitsantas, 2007; Zimmerman, 2000; Studies 1 and 2.
			Bursts	
			Eff	
			Hard	
		Resource management	Enough	
			Pause	
			Keepup	
			Toomuch	
			Concen	
			Help	
	Post action phase	Quality	Forget	Carroll, 1963; Schmitz & Wiese, 2006; J. Stolk et al., 2010; Van der Drift & Vos, 1987; Veenstra et al., 2008; Zimmerman & Kitsantas, 2007; Zimmerman, 2000; Studies 1 and 2.
			Mark	
		Satisfaction	Deepl2	
			Check	
		Self reflection	Prep	
Time on task		Self reported amount of time spent on activities pertaining to study and leisure.		Carroll, 1963; Schmitz & Wiese, 2006; J. Stolk et al., 2010; Van der Drift & Vos, 1987; Veenstra et al., 2008; Zimmerman & Kitsantas, 2007; Zimmerman, 2000; Studies 1 and 2.
Education attributes				
Courses	Number of courses scheduled in one education period		N Courses	Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Van den Berg & Hofman, 2005; Van der Hulst & Jansen, 2002.
Exams	Number of exams scheduled in one education period		N Exams	Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Van den Berg & Hofman, 2005; Van der Hulst & Jansen, 2002.

Shortlisted variables	Rationale	Description of operationalisation	Operationalisation	Rationale for inclusion of variables
Education attributes				
Participatory learning activities	Number of scheduled hours for active teaching formats, such as projects and practicals		N Participatory	Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Van den Berg & Hofman, 2005; Van der Hulst & Jansen, 2002.
Lectures	Number of scheduled hours of lectures		N Lectures	Bruinsma & Jansen, 2007; Jansen & Bruinsma, 2005; Van den Berg & Hofman, 2005; Van der Hulst & Jansen, 2002.
Mandatory learning activities	Number of scheduled hours where presence is mandatory		N Mandatory	Studies 1 and 2.
Student success				
Progress	Number of credits obtained in first year		EC Total	Beekhoven et al., 2002, Van den Berg & Hofman, 2005.

Appendix 4 | Survey First year DUT engineering students cohort 2010

Dear student,

Student success is currently receiving a lot of attention in the media and from policy makers as it affects everyone at Delft University of Technology.

As you probably know, not all the students finish their first year or their course. We would like to find out where the bottlenecks in the courses and curriculum organisation are, so we can start to improve. Therefore we need your help.

In this research we ask all first year students of all the courses in DUT to fill out this survey. This survey is slightly different from the surveys in which you are asked about your opinion on the subjects you took. The questions in this survey do not just deal with education, but also with your personal situation. Another difference between this survey and the regular education surveys is that in this survey we intend to link the outcomes with your data in the Osiris central student database. We do this to find out what factors relating to education matter for student progress. This is important for us to understand where to start with our efforts to improve.

We will treat all your information with great care, we store the information in a safe place and when we report on this research, data and findings will never be retraceable your person. The data will only be used for this research.

By filling out this survey you give us permission to link the outcomes of this survey to your information in Osiris. Filling out the survey will take 10 to 15 minutes.

This research is executed by the Office of Education and Student Affairs together with researchers from the faculty of Technology, Policy and Management. If you have any questions regarding this research, please contact m.e.d.vandenbogaard@tudelft.nl.

Thank you.

Maartje van den Bogaard
Researcher TPM

On behalf of
Director of Student and Teacher Services at the Office of Education and Student Affairs.

1. This survey is only available in Dutch. If you do not speak Dutch, please click here.
   I do not speak Dutch.
2. Please fill out your 7-digit student identification number using the drop down menus.

Prior education

3. Based on what qualification did you enrol in Delft University of Technology?
- Pre university education diploma, focus on natural sciences and technology.
- Pre university education diploma, focus on natural sciences and health.
- Pre university education diploma, focus on natural science and technology and health.
- Entrance exam of DUT.
- First year diploma of university of applied sciences.
- Other, namely……

4. Did you take extra elective courses in pre university education?
- No
- Yes, namely……

5. Is this your first course in tertiary education?
- No (skip to question 8)
- Yes

6. You indicated that you were enrolled in a different course before. Which course? ……

7. Did you finish this course (did you obtain for example a B.A., B.Sc., M.A., etc)?
- No
- Yes

8. What grades did you obtain for mathematics and physics in your exams in secondary school?
   If you are not sure, give an estimation.

Maths	1 2 3 4 5 6 7 8 9 10
Physics	1 2 3 4 5 6 7 8 9 10

9. Have you ever been retained in school?
- No
- Yes

Skills

10. Which languages do you speak and what is your mastery level of these languages?

Dutch	poor	mediocre	fair	good	excellent	not applicable
English	poor	mediocre	fair	good	excellent	not applicable
Other, namely	poor	mediocre	fair	good	excellent	not applicable

11. How do you assess your own skills in these areas:

Maths	poor	mediocre	fair	good	excellent
Physics	poor	mediocre	fair	good	excellent
Computer skills (such as matlab)	poor	mediocre	fair	good	excellent

Housing situation

12. Where do you live right now?

- With my parents/guardians (skip to question 16)
- Housing with private facilities (skip to question 16)
- With a landlord/lady (skip to question 16)
- Housing with shared facilities (student room)
- Other, namely……. (skip to question 16)

13. You indicated that you live in housing with shared facilities. How many flatmates do you have?

Number of flatmates:

14. Is your house associated with a student union (fraternity/sorority)?

- No
- Yes

15. Are any of your flatmates enrolled in the same course you take?

- No
- Yes

Commuting

16. What is your average commuting time for a one way trip from your home address to your faculty?
    Please indicate the commuting time in hours and minutes.
    If your trip takes less than an hour, fill in '0' in the hours box.

Hours: Minutes

17. How many days a week did you come to the faculty during this educational period?
    Average number of travel days:

Unions and associations

18. Are you a member of a student union?
    (multiple answers possible)

- Yes, of a student union in Delft
- Yes, of a sports association in Delft
- Yes, of a sports association close to my parents
- Yes, of a cultural association in Delft
- Yes, of a cultural association close of my parents
- Yes, of my study association
- No, I am not a member of any association
- Other, I am a member of another association or club, namely: ……

Parental level of education

19. Did your parents/guardians graduate from a course in tertiary education (university or university of applied science)?

- One of my parents/guardians
- Both my parents/guardians
- Neither of my parents/guardians
- I do not know.

Impairments

20. Are there attributes that may limit your ability to study, such a learning difficulties or physical impairments?

- No (skip to question 22)
- Yes

21. You indicated that you have some attributes that may limit your ability to study. Can you indicate what these attributes are?
    (multiple answers possible)

- Dyslexia
- (Protracted) Pain
- Limitations regarding moving
- Limitations regarding seeing
- Limitations regarding hearing
- Limitations regarding speaking
- Limitations regarding stamina
- Chronic fatigue

- Concentration problems
- Sleep disorders
- Depression or mood swings
- Fear or panic attacks
- Condition in the autistic spectrum
- Other, namely

Science orientation

22. Indicate with on the statements below is most applicable to you, which one less and which one the least.
    1= most applicable, 2= less applicable, 3= least applicable

- I want to know how things work and how they are assembled. I am good at the sciences and find the study materials interesting. I am not sure what sort of job I would like to have, but it has to fit with what I like to do and what I am good at.
- I enjoy technical gadgets, but I do not feel like tinkering with them when they break down. I found the subjects on the natural sciences boring and old fashioned. In the future I would like to make a lot of money and hold a position with a high status.
- I believe that technology can contribute to developments in society. I think about my future and I will look for a job that allows me to contribute meaningfully to society and that allows me to work with people and work on my personal development.

Expectations

23. Is the level of difficulty of the course as you expected?
- Much more difficult
- More difficult
- As difficult as expected
- Easier
- Much easier

24. Is the course as interesting as you expected?
- Much less interesting
- Less interesting
- As interesting as expected
- More interesting
- Much more interesting

25. Do you expect to obtain a pass to the second year (there is academic dismissal when students fail to obtain less than 30 out of 60 credits in their first year of studying)
- No
- Probably not

- I do not know
- Probably
- Yes

26. How important is it for you to study at DUT/ to graduate form DUT?
- Very unimportant
- Unimportant
- Neutral
- Important
- Very important

27. How important is it for you to obtain your propaedeutical (first year) diploma in one year?
- Very unimportant
- Unimportant
- Neutral
- Important
- Very important

Information on DUT and courses

28. Which sources of information did you use when you were deciding on which course you would enrol in?
(choose between 1 and 5 answers)
- General campus visits to the institute/ courses
- Intensive campus visits, such as masterclasses or student-for-a-day events
- Student mentors through "Beta 1 on 1" at my secondary school
- Campus visit with my secondary school
- Information event from DUT on my secondary school
- Information from my parents and/or peers, such as siblings and friends
- I requested information from DUT/ course myself by telephone or e-mail
- Visit to the 'StudieBeurs" event in Utrecht
- Brochures and other printed information materials from DUT/ courses
- Printed materials from independent sources such as Keuzegids Hoger Onderwijs, Elsevier's 'De Beste Studies" rankings, etc.
- YouTube channel of DUT and/or www.itunesu.tudelft.nl
- Websites of institutes and/or comparison websites such as www.studiekeuze123.nl
- None of these sources of information
- Other sources, namely……..

Reasons for choosing Delft University of Technology

29. Can you indicate if the reasons stated below played a role for you
- prior to your studies (while you were making a choice regarding your field of study)
- now, while you are studying
- after your studies (when you think of the future)

A reason can be valid at different moment in your life, therefore you can tick multiple boxes for the same reason. It is possible that a stated reason does not apply to you, in that case you do not tick any of the boxes for that stated reason.

	Prior	Now	After
– DUT has a good reputation			
– I feel attracted to the city of Delft and its student life			
– Short and/or easy commute			
– The campus atmosphere			
– The faculty atmosphere			
– I can relate to the students who are enrolled in the course			
– I can relate to the teachers in the course			
– The entrance requirements of the course			
– The level of difficulty of the course			
– The content of the curriculum and subjects			
– The balance between time for education and time for relaxation			
– The course's focus on theory			
– The course's focus on practice			
– The curriculum offers a lot of study opportunities during and after the course			
– The curriculum fits well with my capacities			
– I find the curriculum's contents appealing.			
– The support that is offered in the curriculum			
– The possibilities to find a interesting job			
– The possibilities to find a well paid job			
– The possibilities to find a high status job			
– The possibilities to find a job offering many opportunities			

Teacher expertise

32. Below you find statements that have to do with how you perceive the quality of the teachers you have had in the previous educational period.
    We want to get an impression of your perceptions. It is possible that one or two teachers stood out, either in a positive or negative way. If that is the case, you can elaborate in the box below the question.
    5-point Likert scale: -/-= not applicable at all, +/+=completely applicable.

- The teachers can convey and explain the teaching materials well.
- The teachers can explain difficult concepts in different ways.
- The teachers take time to answer questions from the students during lectures.
- The teachers truly master the contents, they really know what they talk about.
- The teachers are available when I have questions.
- The teachers can relate to the students well.
- The teachers are enthusiastic about their subjects.

33. Space to explain or clarify your answers.

Assessment and feedback

34. We want to find out more about how you perceived the assessment in your subjects. Assessment refers to interim feedback on your project or on partial exams, such as COZ. We are also interested in your opinions on the final exams. Below you find statements that have to do with these aspects of assessment. You can elaborate on your answers in the box below the statements.
    5-point Likert scale: -/-= completely disagree, +/+=completely agree, NA= not applicable

In the projects the expectations are clear.
- The interim feedback on your project was constructive (e.g. afterwards you had a clear conception of what needed to be improved upon)
- The interim feedback on your project was consistent (e.g. the teacher held on to the same standards and criteria)
- The final assessment of the project was transparent (e.g. you understood what the assessment and grade were based on)
- In the theoretical subjects the expectations at the exam were clear.
- The feedback on the partial exams was constructive (e.g. afterwards you understood what you had been doing wrong)
- The level of difficulty of the exams was a reflection of the difficulty of the subjects.
- The questions in the exams were a reflection of the contents of the subjects.
- There was enough time to answer the questions in the exams.

35. Space to explain or clarify your answers.

Facilities

36. Below you find statements regarding the facilities that are available to you. Please indicate to what extent you agree with the statements. You can clarify your answers in the box below the statements.

    5-point Likert scale: -/-= completely disagree, +/+=completely agree, NA= not applicable

- There is a positive and stimulating atmosphere in the faculty.
- There are enough quiet places to study in the faculty.
- There are enough quiet places to study on campus.
- There are enough places to relax in the faculty.
- The student-mentor was accessible for me.
- The teacher-mentor was accessible for me.
- The student-counsellors are accessible for me.

37. Space to explain or clarify your answers.

Curriculum organization

38. Sometimes things go wrong in the daily course of events. As long as that does not hinder you, that may not be so bad. Sometimes it gets in your way, for instance when a syllabus is not available in time or when the course load of a subject is not spread evenly over the education period.

    Below you find statements that have to do with the curriculum organization of subjects in the previous period. Please indicate to what extent you experienced hindrance as a results of topics covered in the statements. If you feel the statement does not apply, tick the N.A. box. You can clarify your answers in the box below the statements.

    -/-= a lot of hindrance, -=hindrance, +=a little hindrance, +/+= no hindrance, NA=not applicable

- The course load was unevenly spread over the period.
- The teaching materials were difficult to understand.
- The teaching materials became available too late or not at all.
- It was difficult to find out which books I needed for my subjects.
- I received insufficient feedback on my assignments.
- The subjects of this period did not appeal to me.

39. Space to explain or clarify your answers.

Study behaviour and study strategy

40. Below you find statements regarding your study behaviour and study strategies. Please indicate to what extent they apply to you.
    5-point Likert scale: -/-= not applicable at all, +/+=completely applicable.

- I set personal short-term and long-term goals and stick to them.
- I do not work systematically.
- The tempo of the course is too high for me.
- When I study the teaching materials, I really want to understand them.
- I mainly study for the test.
- I am frequently behind on my schoolwork.
- I work in bursts.
- I come up with and try different strategies to spend my time on independent study efficiently.
- I do not succeed in studying hard enough.
- I do not do enough for my course.

41. Below you find more statements regarding your study behaviour and study strategies. Please indicate to what extent they apply to you.

- I regularly interrupt myself to smoke, drink coffee, take a walk, etc.
- I keep up with the teaching materials as much as possible.
- I have too much on my mind.
- I can concentrate well, even when I find the subject matter difficult.
- When I don’t understand something, I find people who can help me, like the teacher or a flat mate.
- After the exam I quickly forget what the subject was about.
- I want to pass the test, I do not care for the grade.
- When I finish a subject I want to have the feeling I really learned something.
- If I fail an exam, I check the exam to find out what I did wrong.
- If I fail an exam, I prepare myself in a different way for the resit.

Time

42. Please indicate the number of hours you spent on average per week on the following activities in the past education period.
    Submit the average number of hours in whole numbers. If you have not spent any time on an activity, fill in a 0.

- Present at the faculty
- Independent study at home
- Social activity (such as unions, sports, etc)
- Paid employment
- Gaming

Follow up

Thank you for filling out this survey.

Based on the results of this survey we intend to do a follow-u survey on a small number of topics. We intend to do this in February/March 2011.

43. Can we approach you for taking part in this follow up survey? You can still decide at that time whether you participate or not.

- I do not want to be approached.
- I do not object to being approached.

My e-mail address is:

Finish

This is the end of this survey. If you have any questions or comments on this research, please contact m.e.d.vandenbogaard@tudelft.nl. Thank you once again for your participation.

Extra questions for student cohort 2009

In the 'expectations' section the following question was added:
Have you obtained your P-diploma?

The question on 'curriculum organisation' contained two extra items:
There were too many teaching and learning activities where attendance was mandatory.
I had too little time for sports and leisure.

Appendix 5 | Data analysis cohort 2010

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Due to the format of the questions and the nature of items we are interested in, most of the data is not normally distributed. Most of the statistical tests used in this analysis are non-parametric tests. For selection of the tests Field (2009) was consulted.

A5.1 | Student behaviour

A5.1.1	**Correlation analysis on concepts of self regulated learning (SRL)**
Hypothesis	The 20 student behaviour variables cluster around the phases of self regulated learning identified by Zimmerman (2000).
Rationale	Zimmerman discerns 4 phases in Self Regulated Learning: *Phase 1:* pre action phase: var 1 to 5 *Phase 2a:* action phase meta cognitive strategies: var 6 to 9 *Phase 2b:* action phase resource management: var 10 to 15 *Phase 3:* post action phase: var 16 to 20.
Statistic	Spearman Rho correlations two tailed significance testing. This is non-parametric data, so rank order correlations are appropriate.
Notes	Respondents were asked to rate their own study behaviour on 20 items on a Likert scale. Values on all statements that were formulated negatively were recoded. There are many significant correlations between the student behaviour variables, ranging from very small correlation values to a correlation of .572. Many of these correlations are significant on a p-value of .001. The concepts of SRL theory, identified as grey blocks, can be recognized to a small extend in the correlations. *Phase 1:* Goal to Exam does not show much consistency: 4 out of 10 correlations are significant: two weak, one moderate and one strong. *Phase 2a:* Behind to Hard, 3 out of 6 correlations are significant and these effects are reasonable to strong. *Phase 2b:* Enough to Help: 8 out of 15 correlations are significant with moderate to reasonable relations. *Phase 3:* Forget to Prep: 4 out of 10 correlations are significant with mostly moderate relations.
Conclusion	It could be assumed that all student behaviour variables correlate, but based on the theory larger and more correlations would be expected within the Phases. The phases of SRL are not evident from this data.

	Syst	Deepl1	Exam	Tempo	Behind	Bursts	Eff	Hard	Enough	Pause	Keepup	Toomuch	Concen	Help	Forget	Mark	Deepl2	Check	Prep	EC Total
Goal	.412/ .001	.104/.015	.283/.000	.172/.000	.386/.000	.372/.000	.269/.000	.379/.000	.419/.000	2.06/.000	.413/.000	.153/.000	.233/.000	.213/.000	.150/.003	.229/.000	.136/.002	.162/.000	.026/.547	.325/.000
Syst	-		.201/.000	.193/.000	.332/.000	.359/.000	.207/.000	.289/.000	.364/.000	.215/.000	.307/.000	.157/.000	.210/.000			.157/.000	.138/.001	.170/.000		.194/.000
Deepl1		-		.094/.029					.089/.039	.137/.002	.119/.006		.109/.012	.129/.003	.111/.010	.208/.000	.356/.000	.194/.000		.142/.001
Exam			-			.355/.000		.197/.000	.244/.000	.131/.002	.355/.000				.159/.000	.246/.000	.156/.000	.121/.005		.211/.000
Tempo				-				.337/.000	.202/.000	.110/.011	.092/.034	.338/.000	.232/.000	.093/.032	.166/.000	.23/.000	.086/.047	.111/.010		.231/.000
Behind					-	.411/.000		.472/.000	.475/.000	.186/.000	.442/.000	.276/.000	.225/.000	.115/.008	.125/.004	.267/.000		.158/.000		.323/.000
Bursts						-		.371/.000	.497/.000	.224/.000	.371/.000	.150/.001	.179/.000	.155/.000	.150/.001	.207/.000	.124/.004	.174/.000		.211/.000
Eff							-		.148/.001	.086/.047	.191/.000			.168/.000			.092/.034		.115/.008	
Hard								-	.572/.000	.223/.000	.298/.000	.287/.000	.347/.000	.099/.022	.208/.000	.242/.000	.096/.028	.187/.000		.321/.000
Enough									-	.195/.000	.425/.000	.171/.000	.229/.000	.158/.000	.146/.001	.241/.000	.144/.001	.179/.000	-.116/.007	.368/.000
Pause										-	.142/.001	.237/.000	.200/.000	.096/.027				.184/.000		.120/.006
Keepup											-	.126/.004	.172/.000	.131/.002	.181/.000	.236/.000	.233/.000	.112/.010		.225/.000
Toomuch												-	.207/.000		.135/.002.	092/.034				.149/.001
Concen													-	.187/.000	.147/.001	.105/.015	.138/.001	.160/.000		.186/.000
Help														-			.134/.002	.188/.000	.109/.012	.105/.016
Forget															-	.230/.000	.233/.000	.089/.041		
Mark																-	.291/.000	.189/.000		.373/.000
Deepl2																	-	.301/.000	.146/.001	.178/.000
Check																		-	.142/.001	.280/.000

A5.1.2	Underlying structure student behaviour variables
Hypothesis	There is a structure underlying the student behaviour variables that corresponds with SRL theory.
Rationale	This hypothesis follows from failing to accept the hypothesis in table A5.1.1. Clearly, the variables are interrelated, but do not cluster around the concepts from SRL as identified in the literature. There are many and strong correlations, therefore we expect there to be underlying factors that reflect concepts/ pattern of study behaviour.
Statistic	Factor analysis with promax rotation.
Notes	Non-normally distributed data violates the assumptions of Factor Analysis to some extent. However, the sample size is large enough to amend these violations.
Conclusion	These factors do not reflect theory/models on SRL, but they do reflect fairly cohesive concepts from literature that explain study success.

Factor	Variables	Factor name	Explained variance %	Cumulative Explained variance %
1	Goal, Syst, Exam, Behind, Bursts, Enough, Keepup	Study strategy	23.4	23.4
2	Tempo, Hard, Too much, Concen	Study load related	8.4	31.8
3	Deepl1, Deepl2, Check, Prep	Deep learning	7.4	39.2
4	Eff, Help	Concentration	6.4	44.5
5	Pause, Forget, Mark	Surface learning	5.2	50.7

A5.1.3	Factor analysis on student behaviour variables that correlate with total number of obtained credits
Hypothesis	All 20 student behaviour variables have a direct effect on student success, operationalized as total number of credits obtained in the first year.
Rationale	All student behaviour variables are expected to contribute to student success.
Statistic	Spearman Rho correlations two tailed significance testing. This is non-parametric data, so rank order correlations are appropriate.
Notes	Variables in Italics are not significant.
Conclusion	16 of 20 variables have a moderate to apparent correlations with EC Total. One variable has a small correlation with EC Total with a .05>p>.001. Three variables do not have any correlation with EC Total.

	Variable	Belonging to SRL phase	Correlation coefficient	p-value
1	Goal	Pre action	.325	.000
2	Syst	Pre action	.194	.000
3	Deepl1	Pre action	.142	.001
4	Exam	Pre action	.211	.000
5	Tempo	Pre action	.231	.000
6	Behind	Action	.323	.000
7	Bursts	Action	.211	.000
8	Eff	Action	.049	.265
9	Hard	Action	.321	.000
10	Enough	Action	.368	.000
11	Pause	Action	.120	.006
12	Keepup	Action	.225	.000
13	Too much	Action	.149	.001
14	Concen	Action	.186	.000
15	Help	Action	.105	.016
16	Forget	Post action	.031	.484
17	Mark	Post action	.373	.000
18	Deepl2	Post action	.178	.000
19	Check	Post action	.280	.000
20	*Prep*	*Post action*	*.006*	*.895*

A5.1.4	Factor analysis on student behaviour variables that correlate with total number of obtained credits
Hypothesis	There is a strong underlying structure underneath the student behaviour variables that correlate with EC Total.
Rationale	A factor analysis on only the student behaviour variables that correlate with EC Total may show different factors that are meaningful in this study. Factor analysis was performed on all the variables that correlate with EC Total and on the variables that had a p-value of .001 or smaller.
Statistic	Factor analysis with promax rotation, fixed on 4 factors. We assume that the aspects of behaviour are related and therefore orthogonal rotation is appropriate.
Conclusion	The factor analysis yielded 4 scales that were meaningful clusters. We names the variables as showed in the table. We performed a reliability analysis on the factors, but only Discipline came out as a reliable scale.

Factor	Variables	Factor name	Explained variance %	Cumulative Explained variance %	Crohnbach's Alpha
1	Goal, Syst, Exam, Behind, Bursts, Enough, Keepup	Discipline	28.1	28.1	.809
2	Tempo, Hard, Too much	Load	9.4	37.5	.575
3	Deepl1, Mark, Deepl2, Check	Deep Learning	8.7	46.2	.529
4	Pause, Concen	Focus	6.5	52.8	.339

A5.2 | Student disposition

The variables Motivation Course and Motivation Delft are parcelled variables consisting of the sum of scores on a series of dichotomous items. 7 Of these applied to attributes of Delft as an institute for higher education and 10 applied to attributes of the course. Students were asked if these attributes played a role prior to their choice of course, while they were in the course and if they perceive the attributes of importance after graduation. There was no correlation between these variables and between these variables and student behaviour (Spearman Rankorder Correlations). The process of parcelling led to 9 new variables: Delft Prior, Now and After, Course Prior, Now en After, and Job Prior, Now and After.

A5.2.1	**Correlations between expectations, intentions and motivation**
Hypothesis	All disposition variables are related.
Rationale	We are interested in the correlations between these intention variables. If they would correlate strongly, it could be a reason to reduce the number of intention variables.
Test statistic	Spearman rank order correlations
	In the table the correlation and p-value are given.
Conclusion	The commitment variables show a lot of correlations within that cluster, but there are few correlations beyond the cluster. The same goes for the motivation cluster. This does not have to be a bad thing, as these clusters measure different aspects of student disposition.

	Expec Diff	Expec Int	Imp Delft	Imp P	Delft prior	Delft now	Delft aft	Course prior	Course now	Course aft	Job prior	Job now	Job aft
Expec BSA	.264/ .000	.141/ .001	.374/ .000	.106/ .011		.082/ .048	.099/ .017	.119/ .005		.099/ .019			
Expec Diff	-	.140/ .001		.161/ .000			.104/ .012						
Expec Int		-	.188/ .000	.092/ .028		.147/ .000			.108/ .010				
Imp Delft			-	.252/ .000	.084/ .044	.096/ .022	.095/ .022			.086/ .042	.142/ .001	.146/ .001	
Imp P				-								-.083/ .048	
Delft prior					-	.254/ .000	.204/ .000	.353/ .000	.173/ .000	.150/ .000	.187/ .000	.161/ .000	.130/ .002
Delft now						-	.292/ .000	.270/ .000	.526/ .000	.262/ .000	.149/ .00	.133/ .002	.273/ .000
Delft aft							-	.176/ .000	.278/ .000	.401/ .000	.124/ .003	.144/ .001	.229/ .000
Course prior								-	.282/ .000	.243/ .000	.329/ .000	.224/ .000	.130/ .002
Course now									-	.422/ .000	.104/ .013	.241/ .000	.322/ .000
Course aft										-	.128/ .002	.172/ .000	.295/ .000
Job prior											-	.495/ .000	.230/ .000
Job now												-	.194/ .000

A5.3 | Education environment

A5.3.1	**Relations between perceptions of educational environment**
Hypothesis	There are structure underlying the variables of perceived educational environment.
Rationale	Based on correlations between the educational environment variables we expect an underlying structure that may help to free up degrees of freedom in the model.
Test statistic	Factor analyses with promax rotations.
Notes	OO loaded on a single factor. The analysis was repeated without Late and Book because they did not correlate with the behaviour variables. That smaller factor explains more variance. The reliability of the factors is not great. An Alpha should be at least .7 or .8 to be considered reliable (Field, 2009).
Conclusion	The amount of explained variance is not great, neither is it really bad. The factors are meaningful in the sense that they load on recognizable constructs.

Factor	Variables	Factor name	Explained variance %	Cumul.Explained variance %	Crohnbach's Alpha
TC1	Content, Explain, Master, Empathize, Enthusiasm	Teacher didactic competence	40.4	40.4	.715
TC2	Hall, Available	Teacher 'openess'	14.3	54.7	.557
TS1	Proj, Constr, Consist, Trans	Assessment Project	38.3	38.3	.678
TS2	Exp, Feedback, Level, Repres, Time	Assessment Exams	22.8	61.1	.861
FC1	Atm, StudyF, StudyC, Relax	Facilities general	29.8	29.8	.559
FC2	Stmen, Tcmen, Studsup	Facilities support	16.5	46.3	.375
OO1	Spread, Late, Book, Feedback, Courses, Materials	Education organisation	43.2	43.2	.732

A5.4 | Student background variables

A5.4.1	**Gender and aptitude**
Hypothesis	There may be differences between students regarding aptitude that are related to gender.
Rationale	Gender may affect some student attributes.
Test statistic	Student t-test for parametric data.
Conclusion	There is a significant difference between men and women concerning the grade for Physics.

	Variable	Mean/SD men	Mean /SD women	Df	t	p-value
1	SE Maths	7.34/ 1.35	7.28/ 1.21	469	.434	.665
2	SE Physics	7.51/ 1.12	7.05/ 0.99	469	4.114	.000

A5.4.2	Gender and academic skills					
Hypothesis	There are differences between the genders in student dispositions					
Rationale	Gender may affect some student dispositions.					
Test statistic	Mann Whitney test and biserial correlation for effect size.					
Conclusion	There are no differences between men and women regarding language skills in Dutch and English and in maths skills. There are differences between men and women in physics and computer skills.					
Variable	Median/mean men	Median/mean women	U	z	p-value	r
1 Skills Physics	4.0/ 3.81	3.0/ 3.44	19045.500	-5.833	.000	.26
2 Skills Comp	3.0/ 3.26	2.0/ 2.51	15984.000	-7.459	.000	.33

A5.4.3	Prior education and science orientation and academic skills					
Hypothesis	There is a relation between prior education and disposition and between science orientation and academic skills.					
Rationale	These profiles are generally considered to be tough. This may culminate in different assessments of students' academic skills.					
Test statistic	Kruskal Wallis test, Mann Whitney test as post hoc test and rank biserial correlations for effect size.					
Notes	There were no differences found for the science orientation variables.					
Conclusion	We accept that there are differences between students with different UPE profiles on the numerical academic skills.					
Variable					H	p-value
1 Skills Maths					19.364	.000
2 Skills Physics					12.250	.002
3 Skills Computer					6.567	.037
Variable	Median/mean	Median/mean	U	z	p-value	r
Skills Maths						
S&T and S&H	4.0/3.70	3.0/3.13	2606.000	-4.422	.000	.27
S&H and S&T/S&H		4.0/3.62	3055.000	-3.851	.000	.18
Skills Physics						
S&T and S&H	4.0/3.69	3.0/3.31	3088.500	-3.387	.001	.21
S&H and S&T/S&H	3.0/3.31	4.0/3.70	3333.000	-3.337	.001	.15
Skills Computer						
S&T and S&H	3.0/3.11	3.0/2.69	3368.500	-2.492	.013	.15

A5.5 | Student behaviour and student disposition

A5.5.1	**Motivation for Delft, Courses and Job**
Hypothesis	There are correlations between parcelled variables of course and institutional motivation and student behaviour.
Rationale	Institutional, academic and job motivation are included in a number of models that explain student success. There are 9 of these constructs: 3 for institutional motivation, 3 for course motivation and 3 for job motivation.
Test statistic	Spearman rank order correlations.
Notes	Variables that did not show any correlations are not included in the table.
Conclusion	The Job variables did not show any correlations and nor did Delft After. The only stronger correlations with a low p-value, are Deepl1 and 2 on Course After, which indicates that students want to have really learned something when they leave DUT. The course motivation students had prior to enrolling, correlate lightly with 7 student behaviour variables. Correlations are small and the p-values are relatively large. Therefore we conclude that the relation between motivation and behaviour is weak.

	Student behaviour variable	**Delft Prior corr/ p-value**	**Delft Now corr/ p-value**	**Course Prior corr/ p-value**	**Course Now corr/ p-value**	**Course After corr/ p-value**
1	Syst	.111/.010				
2	Deepl1			.106/.014	.090/.036	.190/.000
3	Tempo			.097/.025		
4	Bursts		-.121/.005			
5	Eff			.108/.012		
6	Hard			.093/.031	.100/.020	.088/.042
7	Keepup			.094/.030		
8	Concen	.136/.002				
9	Help	.103/.018	.086/.048	.114/.009		
10	Forget			.089/.041		
11	Deepl2				.109/.012	.145/.001
12	Check					.095/.028

A5.5.2	Intentions, expectations and confidence
Hypothesis	There are effects of expectations, intentions and confidence on student behaviour variables.
Rationale	There is a lot of research that indicates a relation between disposition variables and student success. In our model Behaviour is an important intervening variable between these two elements. Therefore we explore the relation.
Test statistic	Spearman rank order correlations.
Notes	Variables that did not show any correlations are not included in the table.
Conclusion	All correlations are positive, expectations and intentions have a positive relation with student behaviour. The importance of the BSA and P-diploma for effective behaviour is evident from this table, although the correlations are not very large. The expectations regarding the difficulty of the course also shows many correlations with effective behaviour. The importance of studying in Delft and the expectations regarding interest show fewer correlations. The correlations are not very strong, but most of them have low p-values. We therefore conclude that there is a considerable relation between these variables and behaviour.

	Student behaviour variable	Expec BSA corr/ p-value	Expec Diff corr/ p-value	Expec Int corr/ p-value	Imp Delft corr/ p-value	Imp P corr/ p-value
1	Goals	.200/.000		.165/.000	.135/.002	.227/.000
2	Syst	.115/.008				.168/.000
3	Tempo	.406/.000	.372/.000	.147/.001		.190/.000
4	Deepl1	.117/.006	.109/.011		.130/.002	.202/.000
5	Exam					.154/.000
6	Behind	.298/.000	.163/.000		.098/.023	.326/.000
7	Bursts				.103/.017	.179/.000
8	Eff	.096/.027		.111/.010	.105/.015	
9	Hard	.236/.000	.184/.000	.094/.030	.093/.031	.134/.002
10	Enough	.198/.000	.129/.003	.085/.048		.230/.000
11	Pause				.102/.019	.116/.007
12	Keepup	.142/.001		.107/.014	.136/.002	.225/.000
13	Toomuch	.174/.000	.158/.000			.147/.001
14	Concen	.224/.000			.103/.017	.113/.009
15	Help	.136/.002	.100/.022		.099/.023	
16	Forget	.148/.001	.093/.032	.129/.003		.126/.004
17	Mark	.318/.000	.207/.000		.181/.000	.455/.000
18	Deepl2	.183/.000	.157/.000	.090/.039	.216/.000	.309/.000
19	Check	.160/.000	.090/.037	.094/.029	.122/.005	.257/.000
20	Prep				.138/.001	.087/.044

A5.6 | Student behaviour and education environment

A5.6.1	**Students' perceptions of teachers**
Hypothesis	There are effects of perceived teacher quality and student behaviour.
Rationale	We expect that positive perceptions of teacher quality lead to higher scores on the student behaviour variables.
Test statistic	Spearman rank order correlations.
Notes	Variables that did not show any correlations are not included in the table.
Conclusion	The first thing that stands out is that all correlations are positive: perceptions of teachers do not affect study behaviour in any negative way. Tempo, Hard, Toomuch, Forget, Deepl2 correlate with at least 5 teacher related variables. The positive correlations of Forget and Deepo2 indicate that students who perceive their teacher in a positive way, tend to learn for understanding, rather than for just passing the test.

	Student behaviour variable	**Content corr/ p-value**	**Explain corr/ p-value**	**Master corr/ p-value**	**Emp corr/ p-value**	**Enthusiasm corr/ p-value**	**Available corr/ p-value**	**Hall corr/ p-value**
1	Goal							
2	Syst							
3	Tempo	.115/.007	.087/.043		.090/.037	.091/.035	.141/.001	
4	Deepl1					.125/.004		
5	Exam							
6	Behind	.114/.008	.101/.020		.138/.001			
7	Bursts							
8	Eff							
9	Hard	.204/.000	.126/.003		.123/.004	.111/.010	.150/.001	
10	Enough							
11	Pause				.102/.019			
12	Keep up	.150/.000	.097/.026					
13	Too much	.135/.002	.131/.002	.112/.010	.163/.000	.149/.001		.112/.010
14	Concen							
15	Help					.107/.013		
16	Forget	.202/.000	.239/.000	.131/.002	.089/.041	.101/.020	.155/.000	.100/.021
17	Mark	.108/.013						
18	Deepl2	.147/.001	.159/.000	.162/.000		.139/.001	.127/.003	.116/.007
19	Check							.115/.008
20	Prep		.092/.033					

A5.6.2	**Students' perceptions of assessment**
Hypothesis	There are effects of perceived assessment quality and student behaviour.
Rationale	We expect that positive perceptions of assessment quality lead to higher scores on the student behaviour variables.
Test statistic	Spearman rank order correlations.
Notes	Variables that did not show any correlations are not included in the table.
Conclusion	All correlations are positive, so there are no negative effects of perceptions of assessment on study behaviours. In general the variables pertaining to project assessment (Proj, Constr, Consist, Trans) correlate with other student behaviour variables more than the variables pertaining to exams. Project assessment correlates with Behind, Eff and Pause, exams correlates with Tempo, Hard, Keepup, Deepl2. Most correlations have relatively small p-values.

	Student behaviour variable	Proj corr/ p-value	Constr corr/ p-value	Consist corr/ p-value	Trans corr/ p-value	Exp corr/ p-value	Feedback corr/ p-value	Level corr/ p-value	Repres corr/ p-value	Time corr/ p-value
1	Goals	.104/.016			.119/.006					
2	Tempo					.170/.000	.087/.044	.148/.001	.135/.002	.184/.000
4	Deepl1					.085/.049				
5	Behind	.087/.045	.099/.022	.089/.040						
6	Bursts						.091/.035			
7	Eff	.104/.016	.132/.002	.110/.011	.104/.016					
8	Hard					.113/.009	.088/.042	.106/.014	.125/.004	.107/.013
9	Enough	.119/.006			.109/.011					
10	Pause	.094/.030	.125/.004	.097/.026						
11	Keepup	.117/.007				.115/.008	.121/.005	.120/.005	.117/.007	
12	Toomuch	.107/.014				.133/.002			.117/.007	.092/.035
13	Help				.098/.024					
14	Forget			.100/.022		.168/.000	.091/.036	.142/.001	.120/.006	.142/.001
15	Deepl2		.108/.013	.090/.039		.119/.006	.109/.012	.105/.015	.091/.036	
16	Check		.087/.045					-.113/.009		
17	Prep		.106/.015							

A5.6.3	**Students' perceptions of facilities**
Hypothesis	There are effects of perceived quality of facilities and student behaviour.
Rationale	We expect that positive perceptions of quality of facilities lead to higher scores on the student behaviour variables. These hypothesis is based on outcomes of the interviews, where students stated that a good atmosphere was a stimulus that makes them work harder and more willing to put in effort.
Test statistic	Spearman rank order correlations.
Notes	Variables that did not show any correlations are not included in the table.
Conclusion	Teacher mentor did not show any correlations. There are mostly positive correlations, except for two small negative correlations between Student Mentor and Student Support. Atmosphere and Relax correlate with most student behaviour variables, 11 and 7 correlations respectively.

	Student behaviour variable	Atmosphere corr/ p-value	Study Faculty corr/ p-value	Study Campus corr/ p-value	Relax corr/ p-value	Student mentor corr/ p-value	Student support corr/ p-value
1	Goals						107/.013
2	Syst						.098/.023
3	Tempo	.124/.004			.138/.001		
4	Deepl1	.105/.015			.105/.015	.115/.007	
5	Behind					-.097/.025	-.093/.030
6	Eff	.104/.016					

	Student behaviour variable	Atmosphere corr/ p-value	Study Faculty corr/ p-value	Study Campus corr/ p-value	Relax corr/ p-value	Student mentor corr/ p-value	Student support corr/ p-value
7	Hard	.092/.034			.099/.022		
8	Enough	.102/.018					
9	Toomuch	.091/.037	.107/.014		.104/.016		
10	Concen	.175/.000	.089/.041	.111/.010	.097/.025		
11	Help	.200/.000		.129/.003	.091/.036		.101/.020
12	Deepl2	.131/.003				.096/.026	.098/.023
13	Check	.173/.000			.116/.007		
14	Prep	.124/.004		.111/.010		.122/.005	

A5.6.4	**Students' perceptions of educational organisation**
Hypothesis	There are effects of perceived quality of educational organisation and student behaviour.
Rationale	We expect that positive perceptions of quality of educational organisation lead to higher scores on the student behaviour variables. Bruinsma and Jansen (2007) found a positive effect of structure and organisation, but a negative effect of instructional pace.
Test statistic	Spearman rank order correlations.
Notes	Variables that did not show any correlations are not included in the table.
Conclusion	OO Book en OO Late did not show any correlations with the student behaviour variables. There is only 1 negative correlation between Prep and Material. This means that students who have the belief that they will try different ways of studying find the materials difficult to understand. Late and Book do not correlate with any of the student behaviour variables. Material is the only variable with correlations up to .353. These correlations are still not very strong, but much stronger than most other correlations found so far.

	Student behaviour variable	Spread corr/p-value	Material corr/p-value	Feedback corr/p-value	Courses corr/p-value
1	Goal		.093/.032	.090/.036	.119/.006
2	Tempo	.099/.022	.353/.000		
3	Deepl1	.141/.001			.086/.045
5	Behind		.298/.000	.111/.010	.118/.006
6	Eff				.105/.015
7	Hard		.230/.000	.102/.018	.140/.001
8	Enough		.242/.000	.124/.004	.130/.002
9	Keepup			.092/.034	.166/.000
10	Toomuch		.111/.010	.126/.004	
11	Concen	.091/.036			
12	Help			.127/.003	.112/.009
13	Forget	.123/.005	.108/.012	.174/.000	.129/.003
14	Mark	.162/.000	.206/.000	.098/.024	.126/.003
15	Deepl2	.161/.000		.091/.037	.180/.000
16	Check		.131/.002		.087/.045
17	Prep		-.114/.009		

A5.6.5	**Relations among variables of perceived quality of educational environment and behaviour**
Hypothesis	There are correlations between parcelled variables of perceived quality of educational environment and student behaviour.
Rationale	Based on the outcomes of the factor analysis in A5.3.1 we parcelled the variables that loaded on the same factor by adding up the scores. This way the variables become continuous variables that are easier to work with.
Test statistic	Factor analysis with promax rotations and Spearman correlations.
Notes	These correlations show different patterns than the original correlation matrices of A5.6.1 to A5.6.4. The correlations are weak to moderate.
Conclusion	There is a small number of variables that shows a significant correlation with the student behaviour variables. The p-values are small. Factors TC1, TS1, and OO1 show the strongest relation with behaviour.

	Student behaviour variable	**TC1 corr / p-value**	**TC2 corr/ p-value**	**TS1 corr/ p-value**	**TS2 corr/ p-value**	**FC corr/ p-value**	**FC2 corr/ p-value**	**OO corr/ p-value**
1	Behind	.136/.002		.125/.004				.185/.000
2	Check	.116/.008						
3	Concen	.087/.046				.158/.000		
4	Deepl1	.111/.010	.101/.020					.116/.007
5	Deepl2	.171/.000	.136/.002	.109/.012	.139/.001		.093/.032	.144/.001
6	Eff			.133/.002				
7	Enough			.097/.025				.155/.000
8	Forget	.224/.000	.153/.000	.086/.048	.176/.000			.224/.000
9	Goal			.124/.004			.100/.021	.131/.003
10	Hard	.174/.000	.116/.007		.157/.000	.092/.034		.202/.000
11	Help	.103/.017		.126/.004		.160/.000	.112/.009	.094/.030
12	Keepup	.139/.001		.088/.043	.160/.000			.162/.000
13	Mark							.204/.000
14	Pause			.121/.005				
15	Prep		.088/.043	.09/.025		.097/.025	.086/.047	
16	Tempo	.131/.002	.129/.003		.221/.000	.115/.008		.181/.000
17	Too much	.160/.000	.163/.000		.151/.000			.159/.000

A5.7 | Student behaviour and student background variables

A5.7.1	Housing situation
Hypothesis	Housing situation affects all student behaviour variables.
Rationale	Students who live with their parents live in a structured environment, but cannot take part in Delft student life easily. For students who live independently, it is the other way around. Based on these differences, we expect to find differences in student behaviour.
Test statistic	Kruskal Wallis test, Mann Whitney as post hoc test with Bonferroni correction and biserial correlation for effect size.
Notes	1 = parents, 2 = independent living space, 3 = landlord/lady, 4 = student flat. The Bonferroni correction leads to a critical p-value of .05/4=.013.
Conclusion	Housing situation is related to 3 SRL action phase behaviour variables. Students who live with a landlord or lady score higher on Deepl1 than the students who live with their parents or in a student house. On Concen students who live with a landlord or lady score lower. The effect sizes are very small. We reject the relationships because the p-values are too large to be considered after Bonferroni correction. Hypothesis rejected.

	Variable	H	p-value
1	Deepl1	7.867	.049
2	Behind	9.875	.043
3	Hard	11.712	.008
4	Concen	8.208	.042

	Variable	Median/mean	Median/mean	U	z	p-value	r
Deepl1							
1	1 to 3	4.0/4.03	4.0/4.35	2910.00	-2.710	.007	.12
2	3 to 4	4.0/4.35	4.0/4.09	2844.00	-2.290	.022	.10
Behind							
1	1 to 4	3.0/3.33	3.0/3.12	21870.00	-2.127	.033	.09
Hard							
1	1 to 3	3.0/3.25	3.0/2.82	2999.50	-2.296	.022	.10
2	1 to 4	3.0/3.25	3.0/2.97	20764.00	-2.973	.003	.13
Concen							
1	1 to 3	3.0/3.20	3.0/2.74	2958.00	-2.351	.019	.10
2	2 to 3	3.0/3.31	3.0/2.74	510.00	-2.219	.026	.09
3	3 to 4	3.0/2.74	3.0/3.28	2609.00	-2.679	.007	.12

A5.7.2	Membership fraternity
Hypothesis	Membership of fraternity leads to lower scores on all student behaviour variables.
Rationale	It is a popular belief that students who are members of fraternities are less successful than students who are not members. In our model student behaviour is the main predictor of success. Therefore members are expected to score differently. This variable was not included in any of the studies considered for this analysis, but it is included because students that were interviewed thought it might make a difference and because it is often said to make a difference.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	All of the variables except Check are part of the action phase of SRL theory. This is an indication that students who are members of fraternities have more trouble with keeping up with the subjects. Again, the effect sizes are very small, but so are the p-values.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Behind	3.0/3.03	3.0/3.28	25602.500	-2.836	.005	.12
2	Bursts	2.0/2.58	3.0/3.05	22305.000	-4.922	.000	.21
3	Hard	3.0/2.86	3.0/3.19	24402.500	-3.590	.000	.15
4	Enough	3.0/3.06	4.0/3.51	23000.500	-4.448	.000	.19
5	Toomuch	2.0/2.39	3.0/2.71	24341.000	-3.294	.001	.14
6	Check	4.0/3.70	4.0/3.88	24341.000	-2.264	.024	.10

A5.7.3	Membership sports association in Delft
Hypothesis	Membership sports association Delft affects all student behaviour variables.
Rationale	Many sports associations in Delft double as fraternities or are affiliated with fraternities. In our model student behaviour is the main predictor of success. Therefore members are expected to score differently.
Statistic	Mann Whitney test.
Notes	Not significant.
Conclusion	Memberships of sports associations in Delft do not affect study behaviour. Hypothesis rejected.

A5.7.4	Membership sports association at parents
Hypothesis	Membership sports association at Parents affects all student behaviour variables.
Rationale	Many sports associations in the Netherlands double as a social meeting place. In our model student behaviour is the main predictor of success. Therefore members are expected to score differently.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Tempo is the only item that students who are members of sports associations score significantly lower on that students, who are not members of such associations. The effect size is very small. Hypothesis rejected.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Tempo	4.0/3.65	3.0/3.34	16872.500	-3.197	.001	.14
2	Toomuch	3.0/2.83	2.0/2.57	17819.500	-2.138	.033	.09

A5.7.5	Membership cultural association in Delft
Hypothesis	Membership cultural association Delft affects all student behaviour variables.
Rationale	Many cultural associations in Delft double as fraternities or are affiliated with fraternities.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Goal and Exam are part of the pre-action phase of SRL theory, Bursts and Keepup are part of the action phase. Effect sizes are very small. Hypothesis rejected.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Goal	4.0/3.67	3.0/3.08	2026.500	-2.224	.026	.10
2	Exam	3.0/3.25	3.0/2.65	2032.500	-2.223	.026	.10
3	Bursts	4.0/3.67	3.0/2.9	1741.500	-2.764	.006	.12
4	Keepup	4.0/3.83	3.0/3.18	1799.500	-2.646	.008	.11

A5.7.6	Membership cultural association at parents
Hypothesis	Membership sports association Delft affects all student behaviour variables.
Rationale	Many sports associations in Delft double as fraternities or are affiliated with fraternities.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Hard and Toomuch are part of the action phase of SRL theory. Effect sizes are very small. Hypothesis rejected.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Hard	4.0/3.50	3.0/3.07	4676.000	-2.078	.038	.09
2	Toomuch	2.0/2.17	3.0/2.64	4530.500	-2.223	.026	.10

A5.7.7	Membership study association (studievereniging)
Hypothesis	Membership course association affects all student behaviour variables.
Rationale	The course association has a separate position among the associations, because it is closely affiliated with the course students are enrolled in. Often, the course encourages membership of the association and members receive benefits such as discounts on books and study materials. Many students are members solely for that reason. The course association also plays a role in the social dynamics in a course, as it organizes course related activities and it has an office in the faculty that often serves as a social meeting place for students. Some members may be very active, others not.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Hypothesis rejected.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Pause	4.0/3.35	4.0/3.56	31092.500	-2.237	.025	.10
2	Help	4.0/3.61	4.0/3.45	31468.500	-2.113	.035	.09

A5.7.8	Membership non-course related association in Delft
Hypothesis	Membership of any non-course related associations in Delft affects all student behaviour variables.
Rationale	Fraternities, sport and cultural associations often serve as similar social platforms that are different from the social platforms within faculties. This hypothesis is based on the idea that any membership has an effect on student behaviour.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	All the significant variables are part of the action phase of SRL theory. Members score lower on the variables, indicating that they have less trouble with keeping up than students who are not members of non-course related associations. It is possible that students who have more trouble with keeping up with the course, decide not to become a member of a non-course related association. Effect sizes are small.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Behind	3.0/3.09	3.0/3.31	31174.000	-2.753	.006	.11
2	Bursts	2.0/2.74	3.0/3.06	29593.500	-3.663	.000	.16
3	Enough	3.0/3.23	4.0/3.50	30565.500	-3.075	.002	.13
4	Hard	3.0/2.97	3.0/3.20	31246.000	-2.702	.007	.11
5	Toomuch	2.0/2.48	3.0/2.74	30273.500	-2.920	.003	.13

A5.7.9	Membership at any Delft-based association
Hypothesis	Membership at any Delft-based association affects all student behaviour variables.
Rationale	We explore the effect of being a member at any association in Delft to check whether there are combined effects of membership in Delft.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Non-members again score higher on these two variables that are part of the action phase of SRL theory. The effect sizes are again very small. As at least one p-value is relatively large, we reject the hypothesis.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Bursts	3.0/2.83	3.0/3.09	26172.500	-2.718	.007	.12
2	Pause	4.0/3.38	4.0/3.58	26625.000	-2.060	.039	.09

A5.7.10	Membership at any association at parents
Hypothesis	Membership of any association near the parents affects all student behaviour variables.
Rationale	We explore the effect of being a member at any association near the parents.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Members score higher on these two variables that represent the action and post-action phase. The effect sizes are very small.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Tempo	4.0/3.61	3.0/3.34	19431.500	-2.865	.004	.12
2	Deepl2	4.0/3.84	4.0/4.00	20326.500	-2.095	.036	.09

A5.7.11	Membership at any association regardless the location
Hypothesis	Membership of any association regardless of the location affects all student behaviour variables.
Rationale	We explore the effects of membership in general.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	This test yields mixed results. Non-members score lower on Tempo and Check, but higher on Bursts and Pause. The effect sizes are very small, p-values are relatively high. Hypothesis rejected.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Tempo	4.0/3.44	3.0/3.22	21138.500	-2.358	.018	.10
2	Bursts	3.0/2.87	3.0/3.07	21597.000	-1.989	.047	.09
3	Pause	4.0/3.39	4.0/3.64	20628.000	-2.376	.017	.10
4	Check	4.0/3.79	4.0/3.97	21073.000	-.2111	.035	.09

A5.7.12	No membership
Hypothesis	No membership of any association affects all student behaviour variables.
Rationale	We explore the effects of membership in general.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	There are only three behaviour variables affected by no membership, and the effect sizes are weak. Hypothesis rejected.

	Variable	Median/mean No member	Median/mean Member	U	z	p-value	r
1	Tempo	3.0/3.23	4.0/3.45	21598.500	-2.231	.026	.09
2	Pause	4.0/3.67	4.0/3.38	20499.000	-2.664	.008	.12
3	Check	4.0/3.98	4.0/3.79	20976.000	-2.384	.017	.10

A5.7.13	Total number of memberships, academic skills, aptitude, age, impairments, PR activities and commute time.
Hypothesis	The total number of memberships of a student, language skills, aptitude, age and/or number of impairments affects all behaviour variables.
Rationale	So far we tested dichotomous variables on memberships, but many students have multiple memberships.
Statistic	Spearman rank order correlations.
Notes	Variables that did not show any correlations are not included in the table.
Conclusion	All the variables representing aptitude and academic confidence show many positive correlations with student behaviour variables, except for computer skills. This is in line with outcomes from the literature. The total number of memberships and language skills do not have an important relation with behaviour, while maths, physics and computer skills do. Age and the number of impairments reported by the students have some weak effects on some of the behaviour variables that represent behaviours on dealing with course load.

	Member-ship Total corr/ p-value	Skills Maths corr/ p-value	Skills Physics corr/ p-value	Skills Computer corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Age corr/ p-value	N Impair corr/ p-value	PR total corr/ p-value	Commute time corr/ p-value
1 Goal		.092/.033	.098/.023					.125/.004				
2 Syst		.099/.022					.100/.021				.098/.023	
3 Deepl1		.131/.002	.127/.003			.088/.040	.097/.025	.110/.011				
4 Tempo	.096/.027	.271/.000	.316/.000	.248/.000	.134/.002	.110 /.010	.252/.000	.226/.000	-.138/.001	-.204/.000		
5 Bursts	-.110/.011										.090/.037	.089/.039
6 Pause	-.117/.007									-.103/.018		
7 Concen		.161/.000	.122/.005	.161/.000	.087/.045	.086/.047	.163/.000	.189/.000	-.096/.027	-.216/.000	.092/.034	
8 Help	.092/.035					.196/.000						-.130/.003
9 Exam							.128/.003	.096/.027	.089/.039			
10 Behind		.151/.000	.183/.000				.176/.000	.179/.000	-.106/.014	-.165/.000		
11 Hard		.171/.000	.162/.000				.171/.000	.159/.000		-.162/.000		.087/.044
12 Keepup							.129/.003	.135/.002			.110/.011	
13 Toomuch		.125/.004	.107/.014	.125/.004				.098/.024	-.124/.004	-.161/.000		
14 Enough		.103/.017	.090/.038								.108/.012	
15 Forget		.086/.048	.184/.000	.121/.005				.098/.024				
16 Mark		.251/.000	.215/.000				.307/.000	.283/.000			.107/.013	
17 Deepl2		.116/.007	.146/.001				.117/.007	.100/.022			.140/.001	
18 Check		.182/.000					.116/.008	.086/.048			.111/.010	

A5.7.14	Gender
Hypothesis	Women are more successful in studying successfully and will score higher on these items.
Rationale	Gender was included in many studies on student success. Gender is often found to have an effect on success: women are more successful than men.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	Only the significant items are shown.
Conclusion	The women scored higher on the items listed, except for Too Much and Forget. However, there is no significance on a level of p<.001 and the effect sizes are weak. Hypothesis rejected.

	Variable	Median/mean men	Median/mean women	U	z	p-value	r
1	Syst	3.0/3.09	4.0/3.37	19640.000	-2.449	.014	.11
2	Bursts	3.0/2.85	3.0/3.11	19797.000	-2.336	.019	.10
3	Eff	3.0/3.07	4.0/3.37	19180.000	-2.833	.005	.13
4	Enough	3.0/3.22	4.0/3.66	18941.500	-2.979	.003	.14
5	Too much	3.0/2.70	2.0/2.45	19357.000	-2.300	.021	.11
6	Help	4.0/3.48	4.0/3.76	18853.000	-2.806	.005	.13
7	Forget	4.0/3.54	3.0/3.33	19269.000	-2.426	.015	.11
8	Mark	3.0/2.88	3.0/3.14	19511.000	-2.152	.031	.09

A5.7.15	Parental education level
Hypothesis	Students whose parents have no degrees from higher education portray different study behaviour.
Rationale	There is some support that first generation students are less successful than other students. In our model student behaviour is the single predictor of success. Therefore expect first generation students to score differently on these variables.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Parental education has no measurable effect on students' study behaviour. Hypothesis rejected.

	Variable	Median/mean no parents in HE	Median/mean 1 or 2 parents in HE	U	z	p-value	r
1	Help	4.0/3.3	4.0/3.61	18199.500	-3.057	.002	-.13

A5.7.16	Science orientation
Hypothesis	Students' science orientation has an effect on all student behaviour variables.
Rationale	The Beta mentality theory is based on four major categories of interest in science and technology. The first category centres around intrinsic interest in technology, the second around status, the third on a desire to improve the world and the fourth on no interest in technology at all. Students are sorted on their most important driver for their course choice.
Test statistic	Kruskall Wallis (H) and Mann Whitney (U) test as a post test. We calculated biserial correlation (r) for effect size. Bonferroni-correction for post hoc tests with 3 catergories leads to a cut off value for p of .05 / 3= .017.
Conclusion	Students' science orientation is related to Deepl1, Eff, Goal and Mark. The differences occur between the students who are into science and technology for intrinsic motivation and those students who are driven by status. Effect sizes are very small. Hypothesis rejected.

	Variable	H	p-value
1	Deepl1	8.101	.017
2	Eff	6.230	.044
3	Goal	8.482	.014
4	Mark	6.874	.032

	Variable	Median/mean	Median/mean	U	z	p-value	r
Deepl1							
1	1 to 2	4.0/4.17	4.0/4.01	20232.00	-2.255	.024	.09
Eff							
1	1 to 2	3.0/3.01	4.0/3.33	19686.00	-2.498	.012	.11
Goal							
1	1 to 2	3.0/3.02	3.0/3.29	19271.00	-2.836	.005	.12
Mark							
1	1 to 3	3.0/2.96	2.0/2.60	9771.00	-2.658	.008	.12

A5.7.17	Prior Education
Hypothesis	Students with a Science & Technology (S&T) or with a combined Science & Technology and Science & Health (S&H) profile will show more effective study behaviours.
Rationale	The S&T and combined S&T/S&H profiles are known to be the most difficult ones in UPE.
Test statistic	Kruskal Wallis.
Conclusion	There is no effect of prior education on study behaviour. Hypothesis rejected.

	Variable	H	p-value
1	Concen	6.610	.037

A5.7.18	Grade retention
Hypothesis	There is a relation between grade retention and study behaviour.
Rationale	Students who have been retained in a grade are at a disadvantage compared to students who have not been retained.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Grade retention has effects on four behavioural variables. The effect size is small, therefore the hypothesis is rejected.

	Variable	Median/mean not retained	Median/mean retained	U	z	p-value	r
1	Hard	3.0/3.13	2.5/2.74	9769.000	-2.402	.016	.10
2	Concen	3.0/3.23	3.0/2.92	9783.000	-2.311	.021	.10
3	Mark	3.0/2.94	2.0/2.44	9034.000	-3.008	.003	.13
4	Check	4.0/3.87	4.0/3.46	9248.000	-2.872	.004	.12

A5.8 | Student behaviour and education attributes

A5.8.1	Student behaviour and education attributes
Hypothesis	The number of lecture hours, participatory hours and mandatory hours show a positive effect on student behaviour, the number of courses and exams show a negative effect on student behaviour.
Rationale	More educational activities will create circumstances for student to study more effectively. The more courses and exams student have, the more they will be under pressure and they will not be able to study effectively.
Test statistic	Spearman rank order correlations.
Conclusion	Perceptions of the assessment correlate negatively with student behaviour variables. N Participatory and N Exams are the only features of the education environment for which the grand totals are related to the student behaviour variables. The student behaviour variables that have most correlations are Check, Enough, Behind and Help. The other variables have 5 or fewer correlations. Most correlations are small with relatively high p-values. The overall effects of education attributes on behaviour are weak.

	Variable	Term 1 corr/ p-value	Term 2 corr/ p-value	Term 3 corr/ p-value	Term 4 corr/ p-value	Grand total corr/ p-value
N Participatory						
1	Check	.161/.000	-.102/.019	-.179/.000		.187/.000
2	Deepl2			.125/.004		.091/.035
3	Enough	.116/.007	-.139/.001	.135/.002	-.094/.029	.098/.024
4	Help	.145/.001	-.085/.049	.116/.008		-.090/.038
5	Pause			.112/.010		.121/.005
6	Behind	.092/.034	-.119/.006	.097/.025		
7	Mark	.094/.031				
8	Toomuch	-.090/.039				
N Lectures						
1	Check	-.130/.003	.122/.005	-.093/.032	-.090/.032	-.105/.015
2	Tempo			.099/.021		.085/.049
3	Behind		.089/.040			
4	Enough		.087/.044			
5	Mark		.086/.047			
6	Pause		-.102/.019		-.085/.050	
N Mandatory						
1	Check		-.121/.005			-.113/.009
2	Enough	-.107/.013	-.088/.041			-.095/.028
3	Bursts	-.101/.019				
4	Deepl1	.089/.040		.103/.017		
5	Help				-.086/.048	
N Exams						
1	Behind			-.120/.005		-.103/.017
2	Check	-.230/.000		-.185/.000		-.160/.000
3	Enough	-.112/.010		-.140/.001		-.111/.010
4	Goal			-.123/.004		-111/.010

	Variable	Term 1 corr/ p-value	Term 2 corr/ p-value	Term 3 corr/ p-value	Term 4 corr/ p-value	Grand total corr/ p-value
N Exams						
5	Help	-.124/.004		-.104/.017		-.096/.026
6	Mark	-.118/.006		-.085/.049		
7	Bursts			-1.06/.014		
8	Help			-.094/.030		
9	Deepl2				.116/.007	
N Courses						
1	Check			-.091/.036	.098/.023	.086/.047
2	Deepl2		.089/.041	.091/.037	.106/.014	.127/.003
3	Tempo	-.126/.003	-.110/.011			-.113/.009
4	Bursts			-.121/.005		
5	Enough			-.119/.006		
6	Forget			.123/.005		
7	Pause		.094/.030			

A5.9 | Student dispositions and educational environment

A5.9.1	Perceptions of educational environment
Hypothesis	Higher scores on perceived quality of educational environment has a relation with motivation, intention and commitment.
Rationale	Based on the interviews there is reason to believe that educational environment influences motivation. Students like to work harder for courses of which they like the teacher.
Test statistic	Spearman correlation.
Notes	Students' confidence seems to have some relations with how students assess their teachers, specifically the teachers' availability, how well teachers explain. Perceived competence also has a relation with how students perceive their exams and to a lesser extent the assessment in their projects. The expectations students have regarding the level of difficulty and how interesting they find their courses seem to have a relation with how students perceive their teachers. Although correlations are small, they have a low p-value. The expectation to pass the BSA threshold seems to correlate with the perceptions students have of their exams. The importance of studying in Delft and the importance of obtaining the P diploma do not show clear relationships with the perceptions of the educational environment.
Conclusion	We accept that there are relations between dispositions and expectancy, institutional and academic commitment and confidence.

	Expec BSA corr/ p-value	Expec Diff corr/ p-value	Expec Intr corr/ p-value	Imp Delft corr/ p-value	Imp P corr/ p-value
TC Content		.141/.001	.130/.002	.194/.000	
TC Explain	.088/.037	.124/.003	.138/.001	.102/.016	
TC Hall		.169/.000	.143/.001		
TC Master			.108/.011	.097/.022	
TC Available		.125/.003			
TC Empathy		.122/.004	.144/001		
TC Enthus		.101/.016	.196/.000	.107/.011	
TS Proj			.188/.000		.109/.011
TS Constr		.137/.001	.218/.000		

	Expec BSA corr/ p-value	Expec Diff corr/ p-value	Expec Intr corr/ p-value	Imp Delft corr/ p-value	Imp P corr/ p-value
TS Consist			.202/.000	.088/.039	
TS Trans			.151/.000		
TS Explain	.102/.017	.116/.006			.084/.050
TS Feedback		.093/.030			
TS Level	.103/.016	.134/.002			
TS Repres	.115/.007			.098/.022	
TS Time	.130/.002	.156/.000			
FC Atm	.128/.003	.153/.000	.231/.000	.126/.003	.107/.013
FC StudyF					
FC StudyC					
FC Relax		.109/.011	.188/.000	.104/.015	
FC Stmen					
FC Tcmen		.149/.000	.110/.010		
FC Studsup	-.114/.008			.088/.041	
OO Spread		.108/.012			.086/.047
OO Material	.321/.000	.344/.000	.114/.008		.195/.000
OO Late				.088/.041	
OO Book					
OO Feedback		.147/.001		.098/.023	
OO Courses	.164/.000	.103/.016	.239/.000	.104/.016	.104/.015

A5.9.2	**Perceived quality of educational environment and disposition**
Hypothesis	Higher scores on perceived quality of educational environment have a relation with motivation, intention and commitment.
Rationale	Based on the interviews there is reason to believe that educational environment influences motivation. For instance, students like to work harder for courses of which they like the teacher.
Test statistic	Spearman rank order correlation.
Notes	Course motivation does not bring out any clear patterns that we recognize based on the interviews. Institutional motivation correlates with how students experience the number of study spaces on campus.
Conclusion	We reject that course, institution and job motivation have a relation with the perceptions of the education environment.

	Delft prior	Delft now	Delft after	Course prior	Course now	Course after	Job Prior	Job Now	Job After
TC Content	.102/.015				.094/.026	.113/.008			.105/.013
TC Explain					.090/.032	.086/.042	.091/.031		.133/.002
TC Hall		-.088/.036							
TC Master						.115/.006			
TC Available						.095/.025			
TC Empathy					.120/.005				
TC Enthus					.085/.045	.125/.003			
TS Proj									
TS Constr									
TS Consist									
TS Trans									
TS Expectation				.101/.018					.107/.012
TS Feedback					.091/.034				

	Delft prior	Delft now	Delft after	Course prior	Course now	Course after	Job Prior	Job Now	Job After
TS Level									.132/.002
TS Repres									.160/.000
TS Time							.090/.036		.173/.000
FC Atm	.089/.039			.091/.034	.111/.010				
FC StudyF					.099/.020				
FC StudyC	.158/.000	.164/.000		.116/.007	.136/.001	.092/.032			
FC Relax	.132/.002			.126/.003	.146/.001	.113/.008			
FC Stmen				.091/.033		.104/.015	.131/.002		.123/.004
FC Tcmen	.116/.007								
FC Studsup	.096/.025	-.115/.007							
OO Spread					.148/.000	.128/.003	.101/.019		
OO Material				.157/.000					
OO Late		.088/.040	-.085/.049						
OO Book				.086/.046					.097/.025
OO Feedback									
OO Courses				.122/.005					

A5.10 | Student dispositions and student background variables

A5.10.1	Housing situation
Hypothesis	There is a relation between housing situation and disposition.
Test statistic	Mann Whitney tests for non-parametric variables, student t-test for parametric variables.
Notes	Expec BSA, Expec Int, Expec Diff, Imp Delft and Imp P did not show any significant effects on both housing comparisons. There are no differences between parental housing or student housing. The only difference that was found was a between parental housing and independent housing.
Conclusion	There was only one relation found between student disposition and housing situation, a difference on Job After between students who live with their parents and student who live independently. The latter group finds the perspective of a job after the course less important on average. Hypothesis rejected.

Variable	Mean	Mean	F	p-value
Parental v independent housing				
Job after	2.73	2.53	4.626	.032

A5.10.2	Membership and disposition
Hypothesis	There is a relation between membership types and disposition.
Rationale	We expect to find some differences between members and non-members of associations as these have a profound influence on Delft student life.
Test statistic	Mann Whitney tests for non-parametric variables.
Conclusion	We found effects of membership of some kind on three out of 5 disposition variables. The effect sizes are weak, one effect size is moderate of strength. Hypothesis rejected.

Variable	Median/mean No member	Median/mean Member	U	z	p-value	r
No member						
Expec BSA	4.0/4.01	4.0/4.29	24653.000	-2.322	.020	.09
Expec Interest	3.0/3.42	3.0/3.26	25093.500	-2.081	.037	.08
Imp P	4.0/3.73	3.0/3.46	23400.500	-3.052	.002	.13
Fraternity						
Imp P	4.0/3.58	3.0/3.36	30454.500	-2.707	.007	.11
Non course related membership in Delft						
Expec BSA	4.0/4.16	5.0/4.33	31885.500	-2.182	.029	.09
Course and non-course related membership in Delft						
Imp P	4.0/3.73	3.0/3.42	14798.000	-3.202	.001	.16

A5.10.3	Total number of memberships, academic skills, aptitude, age, impairments, PR activies and commute time
Hypothesis	Student attributes concerning prior education, language skills, membership and housing situation affect motivation, intention and commitment.
Rationale	Student attributes like social environment, prior education and language skills affect motivation, intention and commitment.
Test statistic	Spearman rank order correlation.
Notes	Age did not show any correlation. Membership shows some weak correlations with Delft motivation variables. Housing situation shows correlations with P Done, Expec BSA and with Imp P. Students who live in a student house score higher on these three variables than students who live with their parents.
Conclusion	We accept that there are relations between aptitude and self reported academic skills, and dispositions. We reject a relation between disposition and the number of PR activities students participated in. The relation between language skills and dispositions is very weak and therefore rejected. The relation between disposition and number of impairments is negative, but the numbers are too small to be able to make any claims about the implications of impairments for disposition.

	Member-ship total corr/ p-value	Skills Maths corr/ p-value	Skills Physics corr/ p-value	Skills Comp corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Impairment total corr/ p-value	PR total corr/ p-value	Commute time corr/ p-value
Expec BSA	.124/.003	.274/.000	.346/.000	.165/.000	.155/.000	.089/.032	.180/.000	.165/.000	-.161/.000	.097/.020	
Expec Diff		.166/.000	.155/.000	.112/.007			.184/.000	.122/.004			-.090/.031
Imp P	-.112/.007	.225/.000	.204/.000	.092/.028			.189/.000	.202/.000	-.100 /.017		
Delft prior										.212/.000	-.103/.014
Delft now	.133/.001							-.125/.003			
Delft after	.140/.001									.108/.009	
Course prior		.113/.007	.112/.008	.084/.045						.223/.000	
Course now										.089/.035	
Course after	.134/.001		.104/.013				.102/.015			.190/.003	

A5.10.4	Gender						
Hypothesis	There are differences between the genders in student dispositions.						
Rationale	Gender may affect some student dispositions.						
Test statistic	Mann Whitney test for non-parametric data and t-test for parametric data.						
Conclusion	There are some small differences, where the differences in computer skills and UPE grades for physics stand out. There were no effects for gender on Expec BSA, Expec Diff, Expec Interest, Imp Delft and Imp P. Hypothesis rejected.						
	Variable	Median/mean men	Median/mean women	U	z	p-value	r
1	Course now	5.0/5.32	6.0/5.85	22391.500	-1.993	.046	.09
2	Delft prior	2.0/2.19	2.0/2.63	21897.5000	-2.926	.003	.13

A5.10.5	Parental education level						
Hypothesis	Students whose parents have no degrees from higher education portray different study behaviour.						
Rationale	There is some support that first generation students are less successful than other students. We expect that first generation students will score differently on disposition than students whose parents have a degree from higher education.						
Statistic	Kruskal Wallis test, Mann Whitney test as post hoc test and biserial rankorder correlations for effect size.						
Conclusion	Parental education affects only the score on Expec BSA. This effect is moderate and because only one variable is affected, the hypothesis is rejected.						
	Variable					H	p-value
	Expec BSA					8.553	.014
	Variable	Median/mean no parents in HE	Median/mean 1 or 2 parents in HE	U	z	p-value	r
1	Expec BSA	4.0/3.95	4.0/4.32	20126.000	-3.991	.000	.17

A5.10.6	Prior education and science orientation						
Hypothesis	There is a relation between prior education and disposition and between science orientation and disposition.						
Rationale	These profiles are generally considered to be tough. This may culminate in different dispositions.						
Test statistic	Kruskal Wallis/ Mann Whitney as post hoc test.						
Notes	There were no differences found for the science orientation variables.						
Conclusion	Given the relatively large p-values and weak effect sizes, we reject the hypothesis.						
	Variable					H	p-value
1	Delft prior					6.387	.041
2	Delft after					8.737	.013
	Variable	Median/mean	Median/mean	U	z	p-value	r
Delft prior							
	S&T and S&H	2.0/2.19	3.0/2.76	3300.500	-2.424	.015	.15
Delft after							
	S&T and S&H	1.0/.092	1.0/1.28	3522.500	-2.047	.041	.12
	S&T and S&T/S&H	1.0/.092	1.0/1.18	23536.500	-2.620	.009	.12

A5.10.7	Grade retention
Hypothesis	We expect that students who have been retained in a grade during their education career, will score differently on the disposition variables.
Rationale	Students who have been retained, have failed academically at some point in their education careers.
Test statistic	Mann Whitney test and biserial correlations for effect size.
Conclusion	Students who have been retained in a grade score significantly lower than students who have not been retained on the variables shown below. The effect sizes are small, but we accept the hypothesis that grade retention affects student disposition.

	Variable	Median/mean Not retained	Median/mean Retained	U	z	p-value	r
1	Expec BSA	4.0/4.27	4.0/3.96	12748.000	-2.236	.025	.09
2	Imp P	4.0/3.55	3.0/3.22	11655.500	-3.117	.002	.13
3	Delft After	1.0/1.11	1.0/0.91	12813.500	-1.999	.046	.08
4	Course After	1.0/1.99	1.0/1.05	10456.500	-3.197	.001	.13
5	Job After	3.0/2.68	2.0/2.12	10487.000	-3.169	.002	.13

A5.10.8	Dispositions and success
Hypothesis	There is a relationship between the number of credits obtained and student disposition variables.
Rationale	Success leads to more success, so there must be some relation between these variables.
Statistic	Pearson correlation.
Conclusion	All correlations between EC Total and the disposition variables are moderate to strong and have low p-values. This outcome is not surprising, as students who had appropriate expectations of the level of the course or who find it easier than they expected, obtain more credits. Students who have the expectation to obtain positive advice on the BSA and who find obtaining the P-diploma more important, tend to obtain more credits.

	Variable	Correlation coefficient	p-value
1	Expec BSA	.397	.000
2	Expec Diff	.159	.000
3	Expec Interest	.162	.000
4	Imp Delft	.144	.001
5	Imp P	.318	.000

A5.11 | Education environment and education attributes

A5.11.1	Educational attributes and perceptions of educational environment
Hypothesis	Attributes of a course have effect on how students perceive the quality of the educational environment.
Rationale	We assume that an overloaded curriculum, number of exams and education where presence is mandatory, puts a lot of strain on the students and this is reflected in a lower student perception of the quality of the education environment. We also assume that number of hours with active education and lectures will have a positive effect on the perception of educational environment.
Test statistic	Spearman correlations.
Conclusion	Attributes of assessment, specifically the exams, show moderate to strong correlations with the number of participatory learning activities, the number of lectures, exams and courses. Apart from these relations, correlations are not frequent and weak to moderate of strength.

	EC Variable	N Participatory corr/ p-value	N Lectures corr/ p-value	N Mandatory corr/ p-value	N Exams corr/ p-value	N Courses corr/ p-value
1	TC Content		.099/.019		.100/.018	
2	TC Master	-.112/.008	.114/.007		.127/.003	
3	TC Empathize			.109/.010		
4	TS Project	.209/.000	-.122/.004	.102/.017	-.134/.002	
5	TS Constructive	.121/.005				
6	TS Expectations	-.398/.000	.463/.000	.103/.016	.320/.000	-.445/.000
7	TS Feedback	-.187/.000			.241/.000	-.097/.023
8	TS Level	-.407/.000	.434/.000	.186/.000	.321/.000	-.397/.000
9	TS Representation	-.452/.000	.413/.000	.177/.000	.376/.000	-.434/.000
10	TS Time	-.423/.000	.574/.000		.267/.000	-.615/.000
11	FC Atmosphere	.185/.000		-.118/.006	-.113/.008	
12	FC Relax	.086/.044		-.091/.033		
13	FC Student mentor	-.103/.016	.100/.019		.220/.000	-.125/.003
14	FC Teacher mentor			-.086/.044	-.113/.008	
15	FC Student support	.149/.000		-.101/.018		
16	OO Spread			.093/.031		
17	OO Book	-.097/.023	.204/.000			-.169/.000
18	OO Feedback		.117/.006			-.099/.021

A5.12 | Education environment and student background variables

A5.12.1	Housing situation
Hypothesis	Housing situation correlates with perception of quality of educational environment.
Rationale	Students who live independently relate to their environment differently than students who live with their parents.
Test statistic	Mann Whitney.
Conclusion	Housing has some small effects on the perceptions of exam assessment. There are no other differences. Hypothesis is rejected.

	Variable	Median/mean Parental housing	Median/mean Other housing	U	z	p-value	r
Parental v independent housing							
TS	Constr	3.0/2.75	3.0/3.09	30243.000	-2.605	.009	.11
TS	Exp	3.0/3.20	3.0/2.86	30737.500	-2.329	.020	.10
TS	Repres	4.0/3.28	4.0/2.86	30423.500	-2.573	.010	.11
TS	Time	4.0/3.50	4.0/3.06	31076.500	-2.122	.034	.09
TC	Empathize	3.0/3.29	3.0/3.13	32260.000	-2.281	.023	.10
FC	Tcmen	3.0/2.38	3.0/2.76	29956.500	-2.603	.009	.11
Parental v student housing							
TS	Constr	3.0/2.75	3.0/3.15	21557.500	-2.938	.003	.14
TS	Exp	3.0/3.20	3.0/2.82	22219.000	-2.460	.014	.12
TS	Repres	4.0/3.28	4.0/2.81	22003.500	-2.686	.007	.13
TS	Time	4.0/3.50	4.0/3.00	22387.000	-2.332	.020	.11
TS	Trans	3.0/2.47	3.0/2.89	21688.000	-2.836	.005	.13
TC	Empathize	3.0/3.29	3.0/3.09	23093.500	-2.589	.010	.12
FC	StudyC	4.0/3.24	4.0/3.61	22412.000	-2.214	.027	.10
FC	Tcmen	3.0/2.38	4.0/2.89	21210.500	-3.061	.002	.14

A5.12.2	Membership
Hypothesis	Membership of a non-course related association affects student behaviour.
Rationale	Students who are members of associations have more opportunities to learn about ways to negotiate their way through university. We expect to find differences between members and non-members.
Test statistic	Mann Whitney.
Notes	We also tested for effects of fraternity membership, but we did not find any.
Conclusion	Membership of some kind has a weak effect on how students perceive their education environment. There is no clear pattern, but the hypothesis is rejected.

	Variable	Median/mean no member	Median/mean member	U	z	p-value	r
No member							
TS	Consist	3.0/3.01	3.0/2.72	22671.00	-2.060	.039	.09
TS	Level	3.0/2.32	3.0/3.03	20041.50	-3.845	.000	.17
TS	Repres	3.0/2.57	4.0/3.19	21294.50	-3.068	.002	.13
TS	Time	3.0/2.63	4.0/3.43	19475.00	-4.211	.000	.18
OO	Book	4.0/3.06	4.0/3.34	22011.00	-2.363	.018	.10
FC	StudyC	4.0/2.89	4.0/3.48	21326.00	-2.831	.005	.12
FC	Tcmen	4.0/3.00	3.0/2.49	21473.00	-2.672	.008	.11

	Variable	Median/mean no member	Median/mean member	U	z	p-value	r
Membership fraternity							
TC	Explain	4.0/3.42	3.0/3.28	29866.500	-2.005	.045	.08
TS	Feedback	3.0/2.65	30.0/2.37	28242.500	-2.013	.044	.09
FC	Study C	4.0/3.23	4.0/3.66	28118.000	-2.004	.045	.08
OO	Courses	4.0/3.35	3.0/3.22	27593.000	-2.036	.042	.09
Non course related membership in Delft							
TC	Explain	4.0/3.44	3.0/3.30	35160.000	-2.191	.028	.09
FC	StudyC	4.0/3.10	4.0/3.63	32113.000	-2.875	.004	.12
Course and non-course related membership in Delft							
TS	Level	3.0/2.62	3.0/2.98	28296.000	-2.121	.034	.09
TC	Empathize	3.0/3.33	3.0/3.16	29612.500	-2.026	.043	.09
FC	Tcmen	4.0/2.93	3.0/2.46	27182.500	-2.657	.008	.11

A5.12.3	**Total number of memberships, academic skills, aptitude, age, impairments, PR activies and commute time**
Hypothesis	There is a relationship between aptitude and students' perceptions of the education environment.
Rationale	Student attributes are expected to have a relationship with how students perceive their environment.
Statistic	Spearman rank order correlation.
Conclusion	We reject the influence of memberships, language skills and travel time on the perceptions of the education environment. We accept that aptitude has an influence on the perceptions of the education environment. The number of PR activities students participated in, tells a different story: this seems to influence how students perceive the education organisation of their course. The number of impairments brings out interesting relations: there is a slight negative correlation between the number of impairments and the perceptions of teachers' empathy and the representativeness of exams. There are positive correlations between impairments and perceptions of student support and spread of the course load.

	Variable	Membership Total corr/ p-value	Skills Maths corr/ p-value	Skills Physics corr/ p-value	Skills Comp corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Age corr/ p-value	Impairment Total corr/ p-value	PR Total corr/ p-value	Commute time corr/ p-value
1	TC Available			.140/ .001	.166/ .000			.106/ .015					
2	TC Content			.103/ .018	.149/ .001					-.125/ .003		.138/ .001	
3	TC Enth				.089/ .040							.086/ .037	
4	TC Emp									-.106/ .012	-.099/ .024		
5	TC Explain			.125/ .004	.137/ .002					-.085/ .045		.129/ .002	
6	TC Hall				.141/ .001			.145/ .001	.094/ .031				
7	TC Master											.106/ .011	
8	TS Consist							-.110/ .013	-.089/ .044				
9	TS Constr		-.106/ .015	-.118/ .006									
10	TS Feedback		.085/ .049	.138/ .001									

	Variable	Membership Total corr/ p-value	Skills Maths corr/ p-value	Skills Physics corr/ p-value	Skills Comp corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Age corr/ p-value	Impairment Total corr/ p-value	PR Total corr/ p-value	Commute time corr/ p-value
11	TS Exp		.124/ .004					.164/ .000	.162/ .000			.113/ .006	
12	TS Level	.140/ .001	.100/ .022	.134/ .002	.108/ .013			.112/ .011	.137/ .002				
13	TS Repres	.121/ .004	.116/ .007	.149/ .001	.116/ .008					-.118/ .006	-.097/ .028	.102/ .014	
14	TS Trans	-.095/ .026	-.089/ .041		-.088/ .042			-.088/ .045	-.093/ .036	.156/ .000			
15	TS Time	.150/ .000	.118/ .007	.119/ .006						-.094/ .027			
16	FC Atm				.099/ .023							.085/ .039	
17	FC Relax							-.128/ .004	-.106/ .017				
18	FC StudyC	.129/ .003										.081/ .050	-.088/ .047
19	FC StudSup										.134/ .002		
20	FC Stmen	.091/ .033	-.094/ .031	-.097/ .025								.132/ .001	
21	OO Book	.104/ .015	.090/ .037	.100/ .020							.105/ .021	.112/ .007	
22	OO Courses											.133/ .001	
23	OO Feedback			.098/ .024									
24	OO Late											.140/ .001	
25	OO Mandatory					.167/.000	.147/ .001						-.089/ .049
26	OO Material		.154/ .000	.141/ .001	.137/ .002	-.132/ .003		-.130/ 004	-.140/ .002				.144/ .001
27	OO Spread		.127/ .003					-.091/ .043		-.151/ .000	.121/ .007		

A5.12.4	Gender
Hypothesis	Gender affects students perceptions of their education environment.
Rationale	We expect to find differences between male and female students in their percpetions of the education environment.
Test statistic	Mann Whitney test with a biserial correlation for effect size.
Conclusion	Gender affects the perceptions of the education environment. The effect sizes are weak to moderate. The number of relations is large compared to other tests presented in this appendix. Therefore, we accept the hypothesis: there are differences between male and female students in their perceptions of the education environment.

	Variable	Median/mean men	Median/mean women	U	z	p-value	r
1	TS Constr	3.0/2.81	4.0/3.29	19497.000	-3.183	.001	.14
2	TS Exp	4.0/3.19	3.0/2.61	19254.000	-3.383	.001	.15
3	TS Level	3.0/3.10	3.0/2.34	18080.000	-4.266	.000	.19
4	TS Repres	4.0/3.34	3.0/2.45	17602.000	-4.738	.000	.21
5	TS Time	4.0/3.53	3.0/2.70	19042.000	-3.540	.000	.16
6	TS Trans	3.0/2.48	3.0/3.02	19785.000	-2.963	.003	.13
7	TC Available	4.0/3.80	4.0/3.58	21081.500	-2.706	.007	.12
8	TC Content	4.0/3.68	4.0/3.54	22052.000	-2.058	.040	.09
9	TC Empathize	3.0/3.26	3.0/3.10	21928.000	-2.031	.042	.09
10	TC Explain	3.0/3.41	3.0/3.25	21923.000	-2.038	.042	.09
11	TC Master	4.0/4.22	4.0/4.07	21668.000	-2.286	.022	.10
12	FC Atm	4.0/3.99	4.0/4.22	19809.500	-2.973	.003	.13
13	FC Relax	4.0/3.41	4.0/3.68	20489.500	-2.236	.025	.10
14	FC Studsup	3.0/2.55	4.0/2.99	20689.500	-2.035	.042	.09
15	FC Tcmen	3.0/2.40	4.0/2.99	19340.000	-3.004	.002	.14

A5.12.5	Prior education and science orientation
Hypothesis	Student attributes concerning parental level of education, prior education, science orientation affect perceptions of the education environment.
Rationale	Student attributes are expected to have a relationship with how students perceive their environment.
Test statistic	Kruskal Wallis and Mann Whitney tests.
Notes	Parental education only affected one variable, therefore we did not test any further. Science orientation (SO) has three categories: 1 = intrinsically motivated, 2 = externally motivated, 3 = idealistically motivated. Prior education profiles: S&T = Science and Technology, S&H = Science and Health, S&T/S&H = combined profile.
Conclusion	We reject that fraternity and parental level of education influence the students' perceptions of the education environment. Prior education influences how students perceive the exams and assessment in the courses. Science orientation has a minor influence on how students perceive the clarity of examination expectations and on how students perceive the student mentor. In the post hoc tests there were no differences for education organisation of their course.

Variable	H	p-value
Education level parents		
FC Atm	13.595	.001
Science orientation (SO)		
FC Stmen	10.799	.005
TS Exp	6.766	.034
OO Courses	6.312	.043
OO Material	12.049	.002
OO Spread	16.429	.000

Variable	H	p-value
Prior education		
TC Emp	8.358	.015
TS Exp	11.233	.004
TS Level	22.810	.000
TS Repres	18.561	.000
TS Time	12.723	.002
TS Trans	10.539	.005
FC Atm	6.527	.038
FC Stmen	11.694	.003
OO Spread	16.262	.000

Variable	Median/mean no member	Median/mean member	U	z	p-value	r
TC Empathize						
S&T and S&H	3.0/3.30	3.0/2.92	3169.000	-2.383	.017	0.15
S&T and S&T/S&H	3.0/3.30	3.0/3.13	23034.500	-2.135	.033	0.10
TS Exp						
SO1 and SO2	3.0/3.08	3.0/2.73	20724.000	-2.235	.025	0.10
SO2 and SO3	3.0/2.73	4.0/3.26	4843.500	-2.272	.023	0.15
S&T and S&H	3.0/3.00	3.0/2.21	2937.500	-2.812	.005	0.18
S&H and S&T/S&H	3.0/2.21	4.0/3.11	3005.500	-3.287	.001	0.20
TS Level						
S&T and S&H	3.0/2.97	2.0/1.63	2249.000	-4.542	.000	0.29
S&H and S&T/S&H	2.0/1.63	3.0/2.99	2423.500	-4.621	.000	0.28
TS Repres						
S&T and S&H	4.0/3.11	2.0/1.84	2515.500	-3.946	.000	0.25
S&H and S&T/S&H	2.0/1.84	4.0/3.20	2631.500	-4.259	.000	0.26
TS Time						
S&T and S&H	4.0/3.29	1.5/2.08	2810.500	-3.121	.002	0.20
S&H and S&T/S&H	1.5/2.08	4.0/3.45	2889.000	-3.550	.000	0.22
TS Trans						
S&T and S&H	3.0/2.58	4.0/3.39	3053.000	-2.507	.012	0.16
S&H and S&T/S&H	4.0/3.39	3.0/2.39	3012.500	-3.239	.001	0.20
OO Material						
SO1 and SO2	3.0/3.02	3.0/2.94	8377.000	-2.402	.016	0.13
OO Spread						
SO2 and SO3	3.0/2.74	3.0/2.72	4088.000	-2.940	.003	0.18
S&T and S&H	3.0/2.84	2.0/2.11	3053.000	-2.507	.012	0.16
S&H and S&T/S&H	2.0/2.11	3.0/2.88	2731.000	-3.942	.000	0.24
FC Atm						
S&T and S&H	4.0/3.96	4.0/4.24	3201.000	-2.398	.016	0.15
FC Stmen						
S&T and S&H	4.0/3.69	4.0/3.26	3253.000	-2.099	.036	0.13
S&T and S&T/S&H	4.0/3.69	4.0/3.95	22327.500	-1.974	.048	0.09
S&H and S&T/S&H	4.0/3.26	4.0/3.95	3070.500	-3.231	.001	0.20
FC Stmen						
SO2 and SO3	4.0/3.68	4.0/3.85	4508.500	-2.121	.034	0.13

A5.12.6	Grade retention
Hypothesis	Grade retained students will have different perceptions of their education environment than students who have not been retained in a grade at some point in their education careers.
Rationale	Students who have been retained in a grade, have dealth with academic failure at some point in their lives. We expect this to have an effect on their experiences in their education environment.
Test statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Grade retention only affects two education environment variables and the effect is weak. Hypothesis rejected.

	Variable	Median/mean Not retained	Median/mean Retained	U	z	p-value	r
1	TC Empathise	3.0/3.18	3.5/3.46	11454.000	-2.095	.036	.08
2	OO Spread	3.0/2.85	3.0/2.36	9619.500	-2.721	.006	.12

Appendix 6 | Data analysis cohort 2009

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A6.1 | Student behaviour

A6.1.1	**Correlation analysis on concepts of self regulated learning (SRL)**
Hypothesis	The 20 student behaviour variables cluster around the phases of self regulated learning identified by Zimmerman (2000).
Rationale	Zimmerman discerns 4 phases in Self Regulated Learning: *Phase 1:* pre action phase: variables 1 to 5 (Goal, Syst, Temp, Deppl1, Exam). *Phase 2a:* action phase meta cognitive strategies: variables 6 to 9 (Behaind, Bursts, Eff, Hard). *Phase 2b:* action phase resource management: variables 10 to 15 (Enough, Pause, Keepup, Toomuch, Concen, Help). *Phase 3:* post action phase: variables 16 to 20.
Statistic	Spearman Rho correlations two tailed significance testing.
Notes	Respondents were asked to rate their own study behaviour on 20 items on a Likert scale. Values on all statements that were formulated negatively were recoded. There are many significant correlations between the student behaviour variables, ranging from very small correlation values to a correlation of .640. Many of these correlations are significant on a p-value of .001. The concepts of SRL theory, identified as grey blocks, can be recognized to a small extend in the correlations. *Phase 1:* Goal to Exam does not do much. 4 out of 10 correlations are significant: two weak, one moderate and one strong. *Phase 2a:* Behind to Hard, 3 out of 6 correlations are significant and these effects are reasonable to strong. *Phase 2b:* Enough to Help: 8 out of 15 correlations are significant with moderate and reasonably strong relations. *Phase 3:* Forget to Prep: 4 out of 10 correlations are significant with mostly moderate relations.
Conclusion	It could be assumed that all student behaviour variables correlate, but based on the theory larger and more correlations would be expected within the Phases. The phases of SRL are not evident from this data.

	Syst	Tempo	Deepl1	Exam	Behind	Bursts	Eff	Hard	Enough	Pause	Keep up	Too-much	Concen	Help	Forget	Mark	Deepl2	Check	Prep
Goal	.417/ .000	.092/ .042		.138/ .002	.318/ .000	.331/ .000	.283/ .000	.331/ .000	.452/ .000	.118/ .009	.392/ .000	.142/ .002	.172/ .000	.106/ .000		.168/ .000	.168/ .000	.149/ .001	.090/ .020
Syst	-	.109/ .046		.206/ .000	.306/ .000	.447/ .000	.164/ .000	.356/ .000	.407/ .000	.284/ .000	.259/ .000		.230/ .00	.095/ .015	.140/ .002	.125/ .006			
Tempo		-	.099/ .028		.270/ .000		-.093/ .038	.364/ .000	.223/ .000			.178/ .000	.243/ .000			.314/ .000			
Deepl1			-	.119/ .008			.130/ .004	.091/ .043	.104/ .020		.119/ .008		.093/ .039		.179/ .000	.180/ .000	.397/ .000		
Exam				-	.228/ .000	.281/ .000			.209/ .000	.101/ .026	.282/ .000	.091/ .027			.235/ .000	.151/ .001	.190/ .000	.137/ .002	
Behind					-	.430/ .000		.467/ .000	.478/ .000	.101/ .026	.290/ .000	.228/ .000	.184/ .000		.129/ .004	.213/ .000	.072	.134/ .003	
Bursts						-	.091/ .044	.390/ .000	.462/ .000	.218/ .000	.351/ .000	.129/ .004	.147/ .001	.122/ .007	.145/ .001	.142/ .002	.166/ .000	.103/ .023	
Eff							-		.118/ .009		.184/ .000	-.124/ .006		.103/ .022			.193/ .000		.197/ .000
Hard								-	.640/ .000	.204/ .000	.148/ .001	.229/ .000	.296/ .000	.101/ .025		.266/ .000		.143/ .001	
Enough									-	.176/ .000	.346/ .000	.158/ .000	.264/ .000	.110/ .015	.105/ .020	.276/ .000	.159/ .000	.219/ .000	
Pause										-		.174/ .000	.250/ .000		.116/ .010				
Keep up											-		.110/ .015		.122/ .007	.097/ .016	.238/ .000	.194/ .00	.107/ .018
Toomuch												-	.197/ .000		.100/ .027				
Concen													-	.150/ .001	.106/ .019	.124/ .006	.094/ .038		
Help														-			.134/ .003	.197/ .000	
Forget															-		.131/ .004		.093/ .041
Mark																-	.193/ .000	.106/ .019	
Deepl2																	-	.181/ .000	
Check																		-	.152/ .001

A6.1.2	Underlying structure student behaviour variables
Hypothesis	There is a strong underlying structure underneath the student behaviour variables that corresponds with SRL theory.
Rationale	This hypothesis follows from failing to accept the hypothesis in A6.1.1. Clearly, the variables are interrelated and do not cluster around the concepts from SRL as identified in the literature. This could be due to poor formulation of items or to absence of these concepts in this population. There are many and strong correlations, therefore we expect there to be underlying factors that reflect concepts/pattern of study study behaviour.
Statistic	Factor analysis with promax rotation.
Notes	Non-normally distributed data violates the assumptions of Factor Analysis to some extent. However, the sample size is large enough to amend these violations. All variables load distinctly on one factor only. In this solution there are 5 factors that consist of only 2 variables. For modelling purposes this is not ideal.
Conclusion	These factors do not reflect theory/models on SRL, but they do reflect fairly cohesive concepts from literature that explain study success.

Factor	Variables	Factor name	Explained variance %	Cumulative Explained variance %	Crohnbach's Alpha
1	Goal, Syst, Behind, Bursts, Enough, Keepup.	Study strategy	21.1	21.1	.787
2	Mark, Tempo, Hard, Too much	Study load related	9.4	30.5	.557
3	Deepl1, Deepl2	Deep learning	7.1	37.6	.558
4	Pause, Concen	Concentration	6.8	44.3	.390
5	Forget, Exam	Surface learning	5.9	50.3	.392
6	Check, Help	Extraversion	5.1	55.5	.328
7	Prep, Eff	Meta cognition	5.1	60.5	.331

A6.1.3	Factor analysis on student behaviour variables that correlate with total number of obtained credits
Hypothesis	All 20 student behaviour variables have a direct effect on student success, operationalized as total number of credits obtained in the first year (EC Total).
Rationale	All student behaviour variables are expected to contribute to student success.
Statistic	Spearman Rho.
Notes	The first 7 variables have moderate and apparent correlations with EC Total and have p-values that are smaller than .001. One variable has a weak correlation, but the p-value is too large to be considered. The other 4 variables have significant correlations with EC Total, but the correlations are too small to be considered and their p-values are larger than .01 as defined in the cut off scores. The first 7 variables are all contained in the first 2 factors from the factor analysis in the previous hypothesis, explaining about 30% of variance in student behaviour. There are apparent and moderate correlations between most variables in the list below.
Conclusion	Only 7 of 20 variables have a moderate to reasonable correlations with EC Total.

	Variable	Phase of SRL	Correlation coefficient	p-value
1	Goal	Pre action	.181	.000
2	Syst	Pre action	.187	.000
3	Deepl1	Pre action	.089	.048
4	Tempo	Pre action	.245	.000
5	Behind	Action	.274	.000
6	Bursts	Action	.097	.031
7	Hard	Action	.284	.000
8	Enough	Action	.312	.000
9	Pause	Action	.095	.036
10	Too much	Action	.097	.032
11	Concen	Action	.106	.019
12	Mark	Post action	.287	.000

A6.1.4	Factor analysis on student behaviour variables that correlate with total number of obtained credits
Hypothesis	There is a strong underlying structure underneath the student behaviour variables that correlate with EC Total.
Rationale	The previous correlations of student behaviour with EC Total do not reflect the outcomes of the factor analyses. A factor analysis on only the student behaviour variables that correlate with EC Total may show different patterns that will allow for elimination of some of the student behaviour variables.
Statistic	Factor analysis with Promax rotation.
Notes	Hard loads on factors 1 and 2. Toomuch loads on factors 2, 3 and 4. Factor 4 has factor loading of Deepl1: -.562 and Toomuch: .799. This factor is difficult to interpret as a result.
Conclusion	This solution explains a considerable amount of variance, but some variables load on multiple factors. Factor 4 has a negative covariance and is difficult to interpret.

Factor	Variables	Factor name	Explained variance %	Cumulative Explained variance %	Crohnbach's Alpha
1	Goal, Syst, Bursts, Hard, Enough, Behind	Discipline	30.1	30.1	.812
2	Tempo, Mark	Load	10.9	41.5	.479
3	Pause, Concen	Focus	9.8	51.2	.390
4	Deepl1, Toomuch	Deeplearning	9.2	60.4	NA

A6.2 | Student disposition

The variables Motivation Course and Motivation Delft are parcelled variables consisting of the sum of scores on a series of dichotomous items. 7 Of these applied to attributes of Delft as an institute for higher education and 10 applied to attributes of the course. Students were asked if these attributes played a role prior to their choice of course, while they were in the course and if they perceive the attributes of importance after graduation. There was no correlation between these variables and between these variables and student behaviour (Spearman Rankorder Correlations). The process of parcelling led to 9 new variables: Delft Prior, Now and After, Course Prior, Now en After, and Job Prior, Now and After.

A6.2.1	Correlations between expectations, intentions and motivation
Hypothesis	All disposition variables are related.
Rationale	We are interested in the correlations between these intention variables. If they would correlate strongly, it could be a reason to reduce the number of intention variables.
Test statistic	Spearman correlations.
Notes	The intention variables hardly correlate with the motivation variables. Only Expec Int correlates with Course Now and Delft Now and Imp P correlates with Course Now. The motivation variables correlate well with very low p-values. All other correlations are apparent or moderate. Only one correlation in the intention variables is weak. 9 Correlations are too small or not significant. The intention variables correlate well. Again Imp Delft has two moderate correlations, with Expec Int and Imp P.
Conclusion	The commitment variables show a lot of correlations within that cluster, but there are few correlations beyond the cluster. The same goes for the motivation cluster. This does not have to be a bad thing, as these clusters measure different aspects of student disposition.

	Expec Diff corr/ p-value	Expec Int corr/ p-value	Imp Delft corr/ p-value	Imp P corr/ p-value	Delft prior corr/ p-value	Delft now corr/ p-value	Delft after corr/ p-value	Course prior corr/ p-value	Course now corr/ p-value	Course after corr/ p-value	Job prior corr/ p-value	Job now corr/ p-value	Job after corr/ p-value
Expec BSA	.283/ .000			.273/ .000									
Expec Diff	-			.117/ .006									-.094/ .027
Expec Int		-	.164/ .000	.101/ .018		.167/ .000			.149/ .000				
Imp Delft			-	.160/ .000		.099/ .020					.131/ .002	.090/ .033	.104/ .015
Imp P				-					.114/ .007				
Delft prior					-	.248/ .000	.243/ .000	.330/ .000	.194/ .000	.207/ .000	.197/ .000	.223/ .000	.123/ .003
Delft now						-	.339/ .000	.235/ .000	.538/ .000	.212/ .000		.208/ .000	.337/ .000
Delft aft							-	.263/ .000	.330/ .000	.474/ .000	.149/ .000	.270/ .000	.346/ .000
Course prior								-	.383/ .000	.370/ .000	.340/ .000	.277/ .000	.240/ .000
Course now									-	.419/ .000	.158/ .000	.328/ .000	.478/ .000
Course aft										-	.215/ .000	.289/ .000	.343/ .000
Job prior											-	.499/ .000	.207/ .000
Job now												-	.387/ .000

A6.3 | Education environment

A6.3.1	**Relations between perceptions of educational environment**
Hypothesis	There are structure underlying the variables of perceived educational environment.
Rationale	Based on correlations between the educational environment variables we expect an underlying structure that may help to free up degrees of freedom in the model.
Test statistic	Factoranalysis with promax rotation.
Notes	We did separate analyses within the 4 areas of educational environment. Factors that emerged are fairly consistent in the sense that we could clearly see what these factors represent. The reliability of the factors is not great. An Alpha should be at least .7 or .8 to be considered reliable (Field, 2009). That is only the case for two of the factors generated here.
Conclusion	The amount of explained variance is not great, neither is it really bad. The factors are meaningful in the sense that they load on recognizable constructs.

Factor	Variables	Factor name	Explained variance %	Cumulative Explained variance %	Crohnbach's Alpha
TC1	Content, Explain, Master, Empathize, Enthusiasm	Pedagogical competence	40.8	40.8	.719
TC2	Hall, Available	Availability teacher	14.7	55.5	.635

Factor	Variables	Factor name	Explained variance %	Cumulative Explained variance %	Crohnbach's Alpha
TS1	Proj, Constr, Consist, Trans	Project assessment	26.4	26.4	.729
TS2	Exp, Feedback, Level, Repres, time	Course assessment	21.6	48.0	.589
FC1	Atm, StudyF, StudyC, Relax	Atmosphere	28.4	28.4	.618
FC2	Stmen, Tcmen, Studsup	Study support	19.3	47.7	.465
OO1	Spread, Material, Late, Book, Feedback	Curriculum logistics	25.0	25.0	.519
OO2	Courses, Mandatory, Relax	Well being	14.5	39.5	.374

A6.4 | Student background variables

A6.4.1	Gender, aptitude and academic skills
Hypothesis	There are gender-based differences between aptitude.
Rationale	Gender may affect some student attributes.
Test statistic	Student t-test.
Conclusion	We accept the hypothesis that there are relations between student attributes and variables representing motivation, intention and commitment.

	Variable	Mean/SD men	Mean /SD women	Df	F	p-value
1	SE Maths	7.22/1.049	7.18/1.019	566	1.090	.297
2	SE Physics	7.37/.830	6.99/ 967	566	.006	.936

A6.4.2	Gender and academic skills
Hypothesis	There are differences between the genders in student dispositions.
Rationale	Gender may affect some student dispositions.
Test statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	There are no differences between men and women regarding language skills in Dutch and English and in maths skills. There are differences between men and women in physics and computer skills.

	Variable	Median/mean men	Median/mean women	U	z	p-value	r
1	Skills Physics	4.0/4.18	3.0/3.43	25286.000	-5.389	.000	.23
2	Skills Comp	3.0/3.22	3.0/2.59	22290.000	-6.808	.000	.29

A6.4.3	Prior education and science orientation and academic skills
Hypothesis	There is a relation between prior education and science orientation and academic skills.
Rationale	The profiles contain a different set of courses. This may culminate in different assessments of students' academic skills.
Test statistic	Kruskal Wallis/ Mann Whitney as post hoc test and biserial correlation for effect size.
Notes	Prior education profiles: S&T = Science and Technology, S&H = Science and Health, S&T/S&H = combined profile. Science orientation (SO) has three categories: 1 = intrinsically motivated, 2 = externally motivated, 3 = idealistically motivated.
Conclusion	Students with a background in Science and Health score lower on maths, physics and computer skills. Students with intrinsic motivatin for science and technology score significantly higher on maths and physics skills as do students with other science orientations.

Variable	H	p-value
Prior education		
Skills Maths	24.775	.000
Skills Physics	23.611	.000
Skills Computer	19.997	.000
Science orientation		
Skill Maths	20.720	.000
Skill Physics	20.595	.000

Variable	Median/mean men	Median/mean women	U	z	p-value	r
Skills Maths						
S&T and S&H	4.0/3.76	3.0/3.35	10574.500	-4.213	.000	.23
S&H and S&T/S&H	3.0/3.35	4.0/3.79	7499.500	-4.622	.000	.27
SO1 and SO2	4.0/3.82	4.0/3.53	20260.000	-3.964	.000	.18
SO1 and SO3	4.0/3.82	4.0/3.51	10477.000	-3.326	.001	.17
Skills Physics						
S&T and S&H	4.0/3.84	3.0/3.73	10790.500	-4.017	.000	.21
S&H and S&T/S&H	3.0/3.73	4.0/4.34	7568.500	-4.594	.000	.27
SO1 and SO2	4.0/4.18	4.0/3.64	19746.000	-4.447	.000	.21
SO1 and SO3	4.0/4.18	4.0/3.80	11442.000	-2.229	.026	.11
Skills Computer						
S&T and S&H	3.0/3.15	3.0/2.68	10464.500	-4.186	.000	.22
S&H and S&T/S&H	3.0/2.68	3.0/3.15	7958.500	-3.798	.000	.22

A6.5 | Student behaviour and student disposition

A6.5.1	Motivation for Delft, Courses and Job
Hypothesis	There are correlations between parcelled variables of course and institutional motivation and student behaviour.
Rationale	Institutional, academic and job motivation are included in a number of models that explain student success. There are 9 of these constructs: 3 for institutional motivation, 3 for course motivation and 3 for job motivation.
Test statistic	Spearman correlations.
Notes	The only variables that show multiple correlations are Course Now and Course After. Course After correlates with Deepl1 and 2 that are one factor, of which Deepl1 correlates a little with EC Total. There is also a correlation between Course After and Mark. Course Now correlates moderately with Keepup and weak correlations with Deepl2, Help and Prep.
Conclusion	We reject the hypothesis as such, but accept that there are weak effects of the Course motivation variables.

	Student behaviour variable	Delft Prior corr/ p-value	Delft Now corr/ p-value	Delft After corr/ p-value	Course Prior corr/ p-value	Course Now corr/ p-value	Course After corr/ p-value	Job Prior corr/ p-value	Job Now corr/ p-value	Job After corr/ p-value
1	Goal									.103/ .023
2	Syst	.111/.014	.095/.034							.113/ .012
3	Deepl1				.120/.008	.094/.037	.146/.001			
4	Exam									-.097/ .031
5	Behind		.092/.040							
6	Eff				.123/.006	.107/.018				
7	Hard			.094/.037			.105/.020			
8	Enough						.090/.046			.093/ .038
9	Keepup					.186/.000				
10	Toomuch							.090/ .045	.107/ .018	
11	Concen					.103/.023				
12	Help		.111/.014			.135/.003			.126/ .005	
13	Mark						.123/.007			
14	Deepl2				.111/.014	.130/.004	.143/.002	.097/ .031		
15	Pause									.110/ .015
16	Prep		.102/.024			.125/.006	.152/.001	.100/ .027		

A6.5.2	Student behaviour and intentions, expectations and confidence
Hypothesis	There are effects of expectations regarding level of difficulty and interest in the course on student behaviour variables.
Rationale	There is a lot of research that indicates a relation between disposition variables and student success. In our model Behaviour is an important intervening variable between these two elements. Therefore we explore the relation.
Test statistic	Spearman correlations.
Notes	Variables that did not show any correlations are not included in the table.
Conclusion	Hypothesis is accepted. There are clear effects of expectations, intentions and confidence on student behaviour.

	Student behaviour variable	Expec BSA corr/ p-value	Expec Diff corr/ p-value	Expec Interest corr/ p-value	Imp Delft corr/ p-value	Imp P corr/ p-value
1	Goals					.220/.000
2	Syst			.147/.001	.097/.032	.193/.000
3	Deepl1	.142/.002	.103/.023			.145/.001
4	Exam			.151/.001		.103/.022
5	Tempo	.346/.000	.468/.000	.147/.001		.217/.000
6	Behind	.236/.000	.206/.000	.169/.000		.256/.000
7	Bursts			.205/.000		.168/.000
8	Eff	-.092/.041				
9	Hard	.218/.000	.229/.000	.162/.000		.280/.000
10	Enough	.149/.001	.095/.036	.154/.001	.098/.029	.334/.000
11	Pause			.100/.027		
12	Keepup		-.102/.024	.155/.001		.125/.005
13	Toomuch	.094/.037	.122/.007			.105/.020
14	Concen	.160/.000	.177/.000	.193/.000		.157/.000
15	Forget			.104/.021	.123/.006	
16	Help			.228/.000	.115/.011	
17	Mark	.213/.000	.219/.000		.102/.024	.461/.000
18	Deepl2			.160/.000	.199/.000	.108/.016

A6.6 | Student behaviour and education environment

A6.6.1	Students' perceptions of teachers
Hypothesis	There are effects of perceived teacher quality and student behaviour.
Rationale	We expect that positive perceptions of teacher quality lead to higher scores on the student behaviour variables. We expect positive correlations.
Test statistic	Spearman Rho correlations.
Notes	There are few correlations and most of them are weak or moderate of strength. From the teacher perception variables Content, Master, Empathy and Availability show consistency. Only the correlation between Hall and Eff is negative.
Conclusion	We accept that there are some effects of Content, Mastery, Empathize and Availability on a small number of student behaviour variables: Tempo, Keepup, Toomuch, Concen, Help and Forget.

	Student behaviour variable	Content corr/ p-value	Explain corr/ p-value	Master corr/ p-value	Emp corr/ p-value	Enthusiasm corr/ p-value	Available corr/ p-value	Hall corr/ p-value
1	Deepl1			.114/.011				
2	Tempo	.131/.003					.094/.037	
3	Eff							-.101/.024
4	Keep up	.121/.007					.116/.010	
5	Too much		.128/.004		.147/.001		.131/.004	.107/.018
6	Concen	.137/.002		.108/.016	.153/.001		.127/.005	
7	Help		.092/.041			.113/.013	.141/.002	
8	Forget	.141/.002		.172/.000		.105/.021	.122/.007	
9	Deepl2			.137/.002		.113/.012	.098/.029	

A6.6.2	Students' perceptions of assessment
Hypothesis	There are effects of perceived assessment quality and student behaviour.
Rationale	We expect that positive perceptions of assessment quality lead to higher scores on the student behaviour variables. We expect positive correlations.
Test statistic	Spearman Rho correlations.
Notes	Variables that did not show any correlations are not included in the table. There is a small number of correlations between variables representing quality of assessment and student behaviour. No clear patterns emerge. Course expectations correlate moderately well with 7 of the student behaviour variables of which a number correlate with EC Total. The correlation between Tempo and Time is easy to comprehend. If a student has no trouble with the tempo of the course, neither would this student get into trouble with time at the exam. Constr did not show any correlations.
Conclusion	We accept that there is moderate effect of Expectations on a fair number of student behaviour variables.

	Student behaviour variable	Proj corr/ p-value	Consist corr/ p-value	Trans corr/ p-value	Exp corr/ p-value	Feedback corr/ p-value	Level corr/ p-value	Repres corr/ p-value	Time corr/ p-value
1	Goals				.168/.000	.100/.026			
2	Deepl1	-.109/.015			.160/.000				
3	Exam	.112/.013							
4	Tempo				.236/.000		.093/.039	.092/.041	.236/.000
5	Behind	.101/.025			.141/.002				
6	Hard				.169/.000				
7	Enough				.155/.001				
8	Pause	.099/.028			.125/.006				
9	Keepup	.098/.030		.133/.003		.100/.027			-.095/.036
10	Concen			.133/.003	.090/.046			.092/.041	

	Student behaviour variable	Proj corr/ p-value	Consist corr/ p-value	Trans corr/ p-value	Exp corr/ p-value	Feedback corr/ p-value	Level corr/ p-value	Repres corr/ p-value	Time corr/ p-value
11	Help					.123/.007			
12	Forget				.129/.004			.122/.007	
13	Mark				.160/.000				
14	Deepl2		-.097/.031		.172/.000				
15	Check			.105/.019		.146/.001			-.091/.043
16	Prep			.089/.050					

A6.6.3	Students' perceptions of facilities
Hypothesis	There are effects of perceived quality of facilities and student behaviour.
Rationale	We expect that positive perceptions of quality of facilities lead to higher scores on the student behaviour variables. We expect positive correlations.
Test statistic	Spearman Rho correlations.
Notes	Atmosphere has weak and moderate correlations with 10 student behaviour variables. Student support correlates with two student behaviour variables. Behind, Concen and Help have more two correlations with FC variables. No clear patterns emerge. Variables that did not show any correlations are not included in the table.
Conclusion	Teacher mentor did not show any correlations. We accept that there is a relation between Atmosphere and 10 student behaviour variables.

	Student behaviour variable	Atmosphere corr/ p-value	Study Faculty corr/ p-value	Study Campus corr/ p-value	Relax corr/ p-value	Student mentor corr/ p-value	Student support corr/ p-value
1	Goals	.109/.015					
2	Syst	.095/.035					
3	Deepl1	.141/.002					.101/.025
4	Tempo	.148/.001					
5	Behind	.167/.000			.144/.001		
6	Bursts	.134/.003					
7	Eff						.137/.002
8	Hard	.158/.000					
9	Enough	.177/.000					
10	Pause	.090/.045					
11	Keepup	.110/.015					
12	Concen	.172/.000	.124/.006				
13	Help	.172/.000		.137/.002	.091/.043	.115/.011	
14	Forget						
15	Mark	.134/.003					
16	Deepl2	.129/.004					.090/.046
17	Check					.092/.042	.094/.038
18	Prep	.091/.045					.159/.000

A6.6.4	**Students' perceptions of educational organisation**
Hypothesis	There are effects of perceived quality of educational organisation and student behaviour.
Rationale	We expect that positive perceptions of quality of educational organisation lead to higher scores on the student behaviour variables. We expect positive correlations.
Test statistic	Spearman Rho correlations.
Notes	The first thing that stands out is that there are strong, reasonable, moderate and weak correlations with low p-values and that most of these are negative. Spread, Material and Relax seem to be correlated most strongly. Relax has some positive and negative correlations. The weak correlations show relations that do make sense: deep learning could be compromised when books are not available. A student might dislike courses that she cannot keep up with and when she is behind with her work. The relationship between feedback and concentration is harder to explain. Variables that did not show any correlations are not included in the table.
Conclusion	Late did not show any correlations. We accept that there are effects of Spread, Material and Relax and to a lesser extent of Book and Courses.

	Student behaviour variable	**Spread corr/ p-value**	**Material corr/ p-value**	**Book corr/ p-value**	**Feedback corr/ p-value**	**Courses corr/ p-value**	**Mandatory corr/ p-value**	**Relax corr/ p-value**
1	Syst							.095/.036
2	Deepl1	-.095/.036	-.113/.012	-.130/.004				
3	Exam							.100/.027
4	Tempo	-.190/.000	-.428/.000			-.116/.010		-.239/.000
5	Behind		-.152/.001			-.115/.010		
6	Bursts					-.107/.017		.207/.000
7	Eff							.206/.000
8	Hard	-.092/.040	-.248/.000			-.104/.021		
9	Enough		-.155/.001					.157/.001
10	Keepup						-.097/.032	
11	Toomuch	-.264/.000	-.129/.004		-.098/.030			-.265/.000
12	Concen		-.216/.000		-.138/.002			
13	Forget		-.135/.003	-.109/.015				
14	Mark	-.113/.012	-.240/.000					
15	Deepl2							.115/.011

A6.6.5	**Relations between variables of perceived quality**
Hypothesis	There are correlations between parcelled variables of perceived quality of educational environment and student behaviour.
Rationale	Based on the outcomes of the factor analysis in A6.3.1 we parcelled the variables that loaded on the same factor by adding up the scores. This way the variables become continuous variables that are easier to manipulate and allow for other test statistics.
Test statistic	Pearson correlations.
Notes	These correlations show different patterns than the original correlation matrices of 3.1 to 3.4. The correlations are weak to moderate.
Conclusion	There is a small number of variables that shows significant correlations with the student behaviour variables. The p-values are small. Factors TC1 and OO1 show the strongest relation with behaviour.

	Student behaviour variable	**TC1 corr/ p-value**	**TC2 corr/ p-value**	**TS1 corr/ p-value**	**TS2 corr/ p-value**	**FC1 corr/ p-value**	**FC2 corr/ p-value**	**OO1 corr/ p-value**	**OO2 corr/ p-value**
1	Deepl1	.092/.043			.090/.047			-.109/.015	
2	Tempo		.096/.032		.172/.000			-.265/.000	-.159/.000
3	Behind					.093/.038			-.100/.028
4	Eff								.098/.031
5	Hard							-.140/.002	
6	Pause				.097/.032				
7	Keepup	.125/.006	.106/.019	.111/.014					
8	Toomuch	.138/.002	.142/.002		.104/.021			-.200/.000	-.193/.000
9	Concen	.186/.000	.112/.013		.094/.037	.126/.005		-.181/.000	
10	Help	.112/.013	.113/.012		.092/.042	.123/.006			
11	Forget	.172/.000	.122/.007	.091/.043	.099/.029			-.102/.024	
12	Mark							-.185/.000	
13	Deepl2	.092/.041							
14	Check							.104/.022	
15	Prep					.096/.034			

A6.7 | Student behaviour and student background variables

A6.7.1	**Housing situation**
Hypothesis	Housing situation affects all student behaviour variables.
Rationale	Students who live with their parents live in a structured environment, but cannot take part in Delft student life easily. For students who live independently, it is the other way around. Based on these differences, we expect to find differences in student behaviour.
Test statistic	Kruskal Wallis/ Mann Whitney with Bonferroni correction as post hoc test and biserial correlations for effect size.
Notes	We test if there are differences in student behaviour between students who live with their parents, independently, with a landlord/lady or in a student house. 1= parents, 2= independent living space, 3= landlord/lady, 4=student flat. The Bonferroni correction leads to a critical p-value of .05/4=.013. That means that only the difference between live with parent and live with landlady is small enough to be considered significantly different. The Bonferroni correction is extremely conservative, however.
Conclusion	We reject this hypothesis, as housing situation only affects Pause and the p-values are too large to accept the differences as significant under the Bonferroni correction.

	Variable	H	p-value
1	Pause	12.135	.007

	Variable	Median/mean	Median/mean	U	z	p-value	r
Pause							
1	1 to 2	4.0/3.52	4.0/3.33	4059.000	-.964	.335	NA
2	1 to 3	4.0/3.52	3.0/2.85	1662.000	-3.033	.002	0.20
3	1 to 4	4.0/3.52	3.0/3.28	10527.000	-2.115	.034	0.11
4	2 to 3	4.0/3.33	3.0/2.85	426.000	-1.971	.049	0.23
5	2 to 4	4.0/3.33	3.0/3.28	2639.000	-.479	.623	NA
6	3 to 4	3.0/2.85	3.0/3.28	1176.000	-2.208	.027	0.18

A6.7.2	**Membership fraternity**
Hypothesis	Membership of fraternity leads to lower scores on all student behaviour variables.
Rationale	It is a popular belief that students who are members of fraternities are less successful than students who are not members. In our model student behaviour is the single predictor of success. Therefore members are expected to score differently.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	The two variables that have significant effects are Keepup and Check. The p-values are quite large. The effect size of Keepup falls within the cut off scores for effect size.
Conclusion	We reject the hypothesis as such but accept that there is an effect on Keepup.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Keepup	3.0/2.78	3.0/2.96	24633.000	-2.337	.019	0.10
2	Check	3.0/3.12	4.0/3.46	25122.500	-1.969	.049	0.08

A6.7.3	Membership sports association in Delft
Hypothesis	Membership sports association Delft affects all student behaviour variables.
Rationale	Many sports associations in Delft double as fraternities or are affiliated with fraternities. In our model student behaviour is the single predictor of success. Therefore members are expected to score differently.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	Only Help has a small p-value and a moderate effect size. It could be argued that athletes ask for help more easily than students who do not practice sports because they are used to working in teams or working closely with a coach or because they know more people they can ask for help. Syst en Deepl1 correlate with EC Total.
Conclusion	There is only one student behaviour variable that is affected by membership in this category. The p-value is low and the effect size is decent. The hypothesis is rejected as such, but there is an effect.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Syst	3.0/3.05	3.0/3.25	20918.000	-1.994	.046	0.08
2	Deepl1	4.0/3.82	4.0/3.99	21110.000	-1.945	.052	0.08
3	Help	3.0/3.49	3.0/3.41	19379.500	-3.166	.002	0.14
4	Forget	3.0/3.15	3.0/3.21	20754.000	-2.066	.039	0.09

A6.7.4	Membership sports association at parents
Hypothesis	Membership sports association at Parents affects all student behaviour variables.
Rationale	Many sports associations in the Netherlands double as a social meeting place. In our model student behaviour is the single predictor of success. Therefore members are expected to score differently.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	There is one variable with a small effect and a reasonable p-value. The reason why students who are members of sport clubs at their parents report that they pause more often, is unclear.
Conclusion	We reject the hypothesis, there is only one behaviour variable affected by this variable.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Pause	3.0/3.07	4.0/3.41	12596.000	-2.463	.014	0.11

A6.7.5	Membership cultural association in Delft
Hypothesis	Membership cultural association Delft affects all student behaviour variables.
Rationale	Many cultural associations in Delft double as fraternities or are affiliated with fraternities.
Statistic	Mann Whitney test.
Notes	Only Behind and Prep are affected, but the p-values are too large and the effect sizes are so small that this effect is ignored.
Conclusion	Hypothesis rejected: members of cultural associations in Delft do not show study behaviour that is any different from non-members.

A6.7.6	Membership cultural association at parents
Hypothesis	Membership sports association Delft affects all student behaviour variables.
Rationale	Many sports associations in Delft double as fraternities or are affiliated with fraternities.
Statistic	Mann Whitney test.
Notes	No effects.
Conclusion	Hypothesis is rejected: members of cultural associations at the parents do not show study behaviour that is any different from non-members.

A6.7.7	Membership study association (studievereniging)
Hypothesis	Membership course association affects all student behaviour variables.
Rationale	The course association has a separate position because it is closely affiliated with the course students are enrolled in. Often, membership of the association is sponsored by the course and members receive benefits like discounts on books and study materials. Many students are members solely for that reason. The course association also plays a role in the social dynamics in a course, as it organizes course related activities and it has an office in the faculty that often serves as a social meeting place for students. Some members may be very Participatory, others not.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	Only two variables are affected. Only Keepup has a small p-value and the effect size indicates small effect. This is counterintuitive, as one would expect members of a course association to try to stay on top of schoolwork. Neither affected student behaviour variable correlates with EC Total.
Conclusion	Hypothesis is rejected.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Keepup	3.0/2.80	3.0/3.01	26025.500	-2.502	.012	0.11
2	Prep	3.0/3.34	4.0/3.50	26726.500	-1.893	.058	0.08

A6.7.8	Membership non-course related association
Hypothesis	Membership of non-course related associations in Delft affects all student behaviour variables.
Rationale	Fraternities, sport and cultural associations often serve as similar social platforms that are different from the social platforms within faculties. This hypothesis is based on the idea that any membership has an effect on student behaviour.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	Membership has some effects, 5 student behaviour variables are affected, with mostly decent p-values and effect sizes. The first 3 variables cluster together and seem to make sense: members are devoting a little less attention to their studies, seek more help, forget their lessons more quickly and check their their work to a lesser extent. Hard and Enough correlate with EC Total.
Conclusion	Membership has some weak effects, but not on all student behaviour variables. Hypothesis accepted.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Behind	3.0/2.93	3.0/3.13	26745.500	-2.341	.019	0.10
2	Enough	3.0/3.30	4.0/3.49	27240.000	-1.996	.046	0.08
3	Help	4.0/3.58	4.0/3.39	26572.500	-2.359	.018	0.10
4	Forget	3.0/3.07	3.0/3.25	26852.5000	-2.131	.033	0.09
5	Check	3.0/3.15	4.0/3.38	26784.500	-2.142	.032	0.09

A6.7.9	Membership at any Delft-based association
Hypothesis	Membership at any Delft-based association affects all student behaviour variables.
Rationale	We explore the effect of being a member at any association in Delft.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	Students who have a membership score lower on all student behaviour variables below. Membership has effects on 4 variables that correlate with EC Total (Deepl1, Behind, Keepup and Check). These effects are weak with mostly low p-values. Membership has an effect on Check that has low communalities with other student behaviour variables. The effect falls within our range of weak effect sizes and its p-value is smaller than .05.
Conclusion	The hypothesis is rejected as such, but there are effects of Deepl1, Behind, Keepup and Check.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Deepl1	3.0/3.39	3.0/3.36	18662.500	-2.798	.005	0.13
2	Behind	3.0/2.97	3.0/3.21	18660.500	-2.687	.007	0.12
3	Bursts	2.0/2.77	3.0/2.97	19507.000	-2.033	.042	0.09
4	Enough	3.0/3.33	4.0/3.56	19463.500	-2.047	.041	0.09
5	Keepup	3.0/2.81	3.0/3.17	17113.000	-3.753	.000	0.17
6	Check	3.0/3.19	4.0/3.46	18963.500	-2.264	.024	0.10

A6.7.10	Membership at any association at parents
Hypothesis	Membership of any association near the parents affects all student behaviour variables.
Rationale	We explore the effect of being a member at any association near the parents.
Statistic	Mann Whitney test.
Notes	No significant effects.
Conclusion	Reject the hypothesis. There are no effects of being a member at a non-Delft based association.

A6.7.11	Membership at any association regardless the location
Hypothesis	Membership of any association regardless of the location affects all student behaviour variables.
Rationale	We explore the effects of membership in general. As membership near the parents does not have an effect, we expect that we find fewer effects than in 2.10.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	There are three student behaviour variables affected, of which two have an effect size that falls within the range of acceptable effect sizes. There are Keepup and Check. These two also had effects for Delft-based associations. Prep has an effect size that is too small to be considered here, but it did not show up in previous Mann Whitney tests.
Conclusion	We reject the hypothesis: being a member of any association regardless location does not have an effect.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Keepup	3.0/2.85	3.0/3.09	14566.500	-2.384	.017	0.11
2	Check	3.0/3.21	4.0/3.48	14814.500	-2.134	.033	0.10
3	Prep	3.0/3.37	4.0/3.59	14892.500	-2.069	.039	0.09

A6.7.12	**No membership**
Hypothesis	No membership of any association affects all student behaviour variables.
Rationale	We explore the effects of membership in general.
Statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	There are only three behaviour variables affected by no membership, and the effect sizes are weak. Hypothesis rejected.

	Variable	Median/mean member	Median/mean no member	U	z	p-value	r
1	Keepup	3.0/2.84	3.0/3.09	14566.500	-2.384	.017	.10
2	Check	3.0/3.20	4.0/3.48	14814.500	-2.134	.033	.09
3	Prep	3.0/3.37	4.0/3.59	14892.500	-2.069	.039	.09

A6.7.13	**Total number of memberships, academic skills, aptitude, age, impairments, PR activities and commute time**
Hypothesis	There is a relationship between memberships, academic skills, aptitude, age, impairments, PR activities and weekly commuting time and student behaviour.
Rationale	Aptitude influences study behaviour. If students have a lot of aptitude, they are likely to need less time to master subject matter.
Test statistic	Pearson correlations.
Notes	Variables that did not show any correlations, such as PR Total, are not included in the table.
Conclusion	All the variables representing aptitude and academic skills have many positive correlations with student behaviour variables, except for computer skills. This is in line with outcomes from the literature. The total number of memberships and language skills have only few correlations that are small and have relatively high p-values. We reject that these variables have effects on behaviour. Most of the correlations between behaviour and impairments are negative. This is to be expected, as students with impairments will have more trouble keeping up constant discipline.

	Variable	Membership Total corr/ p-value	Skills Maths corr/ p-value	Skills Physics corr/ p-value	Skills Comp corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Age corr/ p-value	Impairments N corr/ p-value	Commute time corr/ p-value
1	Goals		.106/ .019								-.105/ .020	
2	Behind	-.110/ .015	.106/ .019				-.090/ .045					.100/ .026
3	Bursts					-.143/ .001	-.141/ .002					.099/ .028
4	Check	-.091/ .044										
5	Concen		.185/ .000	.149/ .001	.108/ .017			.105/ .021	.178/ .000		-.097/ .033	
6	Deepl1		.123/ .006			.118/ .009	-.096/ .032		.090/ .046			
7	Enough		.163/ .000				-.150/ .001	.094/ .037				
8	Exam									.109/ .017		
9	Hard		.209/ .000	.097/ .032			-.096/ .034	.154/ .001	.133/ .003			
10	Pause											.148/ .001

	Variable	Membership Total corr/ p-value	Skills Maths corr/ p-value	Skills Physics corr/ p-value	Skills Comp corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Age corr/ p-value	Impairments N corr/ p-value	Commute time corr/ p-value
11	Keepup	-.120/ .008					-.096/ .033					.131/ .004
12	Mark		.312/ .000	.184/ .000	-			.318/ .000	.330/ .000	.106/ .020		
13	Deepl2					.097/ .032	.103/ .022					
14	Forget			.103/ .023	.132/ .003						.122/ .007	.101/ .025
15	Tempo		.345/ .000	.228/ .000	.153/ .001	.121/ .007		.314/ .000	.247/ .000		-.137/ .002	
16	Toomuch										-.198/ .000	
17	Syst						-.111/ .014					
18	Prep	-.102/ .024				.101/ .026						

A6.7.14	**Gender**
Hypothesis	Gender has an effect on all student behaviour variables.
Rationale	Gender was included in many studies on student success. Gender is often found to have an effect on success: women are more successful than men. In engineering this effect has been debated.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	There are significantly different scores between men and women on 5 variables. The effect size of gender falls within the cut off scores for 4 out of 5 of the student behaviour variables. Of these variables Enough, Bursts and Toomuch correlate with EC Total. These variables are contained in factors that have to do with intrinsic motivation and surface learning.
Conclusion	There are effects of gender that fall within the cut off scores for effect size. Only two correlations have a small p-value. Hypothesis rejected.

	Variable	Median/mean men	Median/mean women	U	z	p-value	r
1	Bursts	2.0/2.70	3.0/3.05	20103.500	-3.304	.001	0.15
2	Eff	3.0/3.14	4.0/3.38	21570.000	-2.219	.026	0.10
3	Enough	3.0/3.26	4.0/3.68	19104.500	-4.013	.000	0.18
4	Too much	2.0/2.55	2.0/2.32	21190.000	-2.407	.016	0.11
5	Forget	3.0/3.20	3.0/3.03	21655.500	-2.056	.040	0.09

A6.7.15	Parental education level
Hypothesis	Students whose parents have no degrees from higher education portray different study behaviour.
Rationale	There is some support that first generation students are less successful than other students. In our model student behaviour is the single predictor of success. Therefore first generation students should score differently.
Statistic	Mann Whitney test and biserial correlation for effect size.
Notes	The effect sizes of Deepl1 is falls within our cut off score for effect size, Forget does not. Deepl1 correlates weakly with EC Total.
Conclusion	There are few effects. These effects show some effect on deep learning: students whose parents have not attended HE themselves, score higher on two deep learning variables. Unfortunately, there are no significant effects of related deep learning variables and that makes it difficult to interpret these outcomes. There is an effect on a variable that correlates with EC Total. We reject the hypothesis.

	Variable	Median/mean no parents in HE	Median/mean 1 or 2 parents in HE	U	z	p-value	r
1	Deepl 1	4.0/4.08	4.0/3.90	19641.000	-2.296	.022	0.10
2	Forget	3.0/3.15	3.0/3.11	19653.500	-2.040	.041	0.09

A6.7.16	Science orientation
Hypothesis	Students' science orientation has an effect on all student behaviour variables.
Rationale	The Beta mentality theory is based on four major categories of interest in science and technology. The first category centres around intrinsic interest in technology, the second around status, the third on wanting to improve the world and the fourth on no interest in technology at all. Students are sorted on their most important driver for their course choice. No Interest in Technology was not included as it did not seem applicable. There are three categories of students.
Test statistic	Kruskall Wallis, Mann Whitney test with Bonferroni correction and biserial correlations for effect size.
Notes	The students only differ on Concen and Eff according to the KW test. Based on the p-value of the KW test for Concen we would not consider it any further. We tested the three groups against each other using separate Mann Whitney tests. To avoid alpha-slippage we use the Bonferroni correction for p-values, meaning we only consider p-values of .0167 and smaller as significant. The effect sizes of the differences fall within our cut off values for effect size.
Conclusion	Students with an intrinsic motivation and students who want to improve the world score higher on Eff than the status driven students. Effects are too small, hypothesis rejected.

	Variable	H	p-value
1	Concen	11.021	.051
2	Eff	20.543	.001

	Variable	Median/mean	Median/mean	U	z	p-value	r
Concen							
1	1 to 2	3.0/3.32	3.0/2.98	10835.500	-1.098	.272	NA
2	1 to 3	3.0/3.32	3.0/3.09	15776.500	-2.312	.021	NA
3	2 to 3	3.0/2.98	3.0/3.09	5952.000	-.834	.404	NA
Eff							
1	1 to 2	3.0/3.17	3.0/3.06	9333.500	-2.924	.003	0.12
2	1 to 3	3.0/3.17	4.0/3.36	16440.500	-1.800	.072	NA
3	2 t o3	3.0/3.06	4.0/3.36	5178.500	-2.486	.013	0.10

A6.7.17	Prior Education					
Hypothesis	Students with a S&T or S&T/S&H profile will show more effective study behaviours.					
Rationale	The S&T and combined S&T/S&H profiles are known to be the most difficult ones in UPE.					
Test statistic	Kruskal Wallis/ Mann Whitney as post hoc test with a Bonferroni correction and biserial correlation for effect size.					
Conclusion	There is no effect of prior education on study behaviour. Hypothesis rejected.					
	Variable				**H**	**p-value**
1	Bursts				8.292	.016
2	Deepl1				7.478	.024
3	Toomuch				8.947	.011

	Variable	Median/mean	Median/mean	U	z	p-value	r
Bursts							
	S&T and S&T/S&H	3.0/2.86	3.0/2.90	11676.500	-2.414	.016	0.13
	S&H and S&T/S&H	3.0/3.05	3.0/2.90	6742.500	-2.605	.009	0.16
Toomuch							
1	S&T and S&H	3.0/2.66	2.0/2.37	9838.000	-2.332	.020	0.13
	S&T and S&T/S&H	3.0/2.66	2.0/2.58	11422.500	-2.657	.008	0.15
Deepl1							
1	S&T and S&T/S&H	4.0/4.04	4.0/4.14	11534.500	-2.633	.008	0.15

A6.7.18	Grade retention
Hypothesis	There is a relation between grade retention and study behaviour.
Rationale	Students who have been retained in a grade are at a disadvantage compared to students who have not been retained.
Test statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Grade retention has effects on four behavioural variables. The effect size is small, therefore the hypothesis is rejected.

Variable	Median/mean Not retained	Median/mean Retained	U	z	p-value	r
Syst	3.0/3.23	3.0/2.87	9406.000	-2.389	.017	.11
Enough	4.0/3.44	3.0/2.91	8467.500	-3.383	.001	.15
Goal	3.0/3.20	3.0/2.85	9023.000	-2.842	.004	.13

A6.8 | Student behaviour and educational attributes

A6.8.1	**Student behaviour and educational attributes**
Hypotheses	The number of lecture hours, participatory hours and mandatory hours show a positive effect on student behaviour, while the number of courses and exams has a negative effect on student behaviour.
Rationale	More educational activities are better. Jansen (1996) found a positive effect of small numbers of courses scheduled at the same time and a small number of exams in one term.
Test statistic	Spearman Rho.
Notes	The correlations for lecture hours and mandatory hours are negative. The correlations for Participatory hours are positive. Participatory hours has the most positive correlations, when we discern between educational period and when we look at the grand total of the year. For N Courses there only seems to be an effect in the third educational period. There are two weak and two moderate correlations. The grand total only correlates weakly with Check. N Exams has 5 and 4 correlations in educational periods 1 and 3. In the grand total there are two moderate correlations and one weak one.
Conclusion	We accept that there are relations between Tempo, Behind, Hard, Enough and Check and some educational attributes. For N Courses and N Exams there are effects, but mostly on the level of the educational periods. For now we accept effects of Exams on Tempo, Behind, Bursts, Hard and Enough. We also accept effects of Courses on Tempo, Behind, Hard, Enough and Check.

	Student behaviour variable	**Period 1 corr/ p-value**	**Period 2 corr/ p-value**	**Period 3 corr/ p-value**	**Period 4 corr/ p-value**	**Grand total corr/ p-value**
N Participatory						
1	Syst					.098/.035
2	Behind	.240/.000	-.120/.009	.223/.000		.269/.000
3	Bursts	.132/.004	-.141/.002	.153/.001	-.130/.005	.105/.024
4	Hard	.161/.000	-.093/.046	.183/.000		.177/.000
5	Enough	.174/.000	-.116/.012	.194/.000		.210/.000
6	Tempo				.092/.048	.133/.004
7	Mark					.095/.041
N Lectures						
1	Tempo	-.105/.023			-.143/.002	-.108/.019
2	Behind	-.175/.000		-.165/.000	-.131/.005	-.195/.000
3	Hard	-.126/.006		-.109/.018		-.128/.006
4	Enough	-.136/.003		-.120/.010	-.099/.032	-.150/.001
5	Concen	-.112/.016	-.126/.006	-.100/.031	-.099/.033	-.115/.013
6	Check			.099/.034		
N Mandatory						
	Syst	-.095/.040				
1	Tempo		-.152/.001	-.129/.005	-.114/.014	-.141/.002
2	Behind	-.156/.001	-.181/.000	-.130/.005	-.127/.006	-.191/.000
3	Bursts	-.143/.002				-.093/.044
4	Hard		-.093/.046			-.099/.032
5	Enough	-.122/.008	-.130/.005			-.138/.003
6	Check	-.119/.010	-.125/.007	-.146/.002		-.118/.011

Student behaviour variable	Period 1 corr/ p-value	Period 2 corr/ p-value	Period 3 corr/ p-value	Period 4 corr/ p-value	Grand total corr/ p-value
N Exams					
Syst					-.105/.024
Tempo	-.129/.005				
Behind	-.250/.000	.116/.012	-.208/.000	.158/.001	-.141/.002
Bursts	-.129/.005		-.145/.002	.115/.013	
Eff					-.108/.020
Hard	-.228/.000		-.206/.000		-.175/.000
Enough	-.230/.000		-.119/.000	.106/.022	-.168/.000
Check		-.113/.015			
N Courses					
Tempo			-.133/.004		
Behind		.098/.035	-.175/.000	.105 .023	
Hard		.111/.017	-.136/.003		
Enough		.091/.049	-.152/.001		
Check	-.142/.002	-.162/.000		-.103/.027	-.149/.001

A6.9 | Student disposition and education environment

A6.9.1	Expectations, intentions and confidence and perceptions of educational environment
Hypothesis	Higher scores on perceived quality of educational environment has a relation with motivation, intention and commitment.
Rationale	There is a lot of reason to believe that educational environment influences motivation, based on the interviews. Student like to work harder for courses of which they like the teacher.
Test statistic	Spearman correlation.
Notes	Perceived quality of teachers affect expectations of interest. Engaging teachers generate more interest of students, en more than students would have expected. A good quality of assessment and atmosphere seem to have similar effects. Atmosphere correlates mildly with motivation for Delft as in institute for higher education. This parcelled variables also includes one item on atmosphere, so correlation is to be expected. There are only a few effects of educational organisation. There is an apparent negative correlation between Expec Int and Courses. If the students find the courses less appealing (higher score on Courses) Expec Int becomes smaller. This correlation is to be expected.
Conclusion	We accept that there are relations between dispositions and expectancy, institutional and academic commitment and confidence.

	Expec BSA corr/ p-value	Expec Diff corr/ p-value	Expec Int corr/ p-value	P done corr/ p-value	Imp Delft corr/ p-value	Imp P corr/ p-value
TC Content			.258/.000	.110/.012		.126/.004
TC Explain			.171/.000		.097/.026	.105/.016
TC Hall				.111/.012		.105/.017
TC Master			.161/.000		.106/.015	
TC Available				.092/.037		.103/.019
TC Empathy			.095/.030		.090/.039	
TC Enthusiasm			.238/.000		.120/.006	
TS proj			.152/.001			
TS Constr			.146/.001			
TS Consist			.120/.006			

	Expec BSA corr/ p-value	Expec Diff corr/ p-value	Expec Int corr/ p-value	P done corr/ p-value	Imp Delft corr/ p-value	Imp P corr/ p-value
TS Exp	.175/.000	.101/.022	.118/.007	.171/.000		.132/.003
TS Feedback			.115/.009			.108/.014
TS Level					.093/.035	.095/.031
TS Repres						
TS Time	.164/.000	.179/.000		.123/.005		
FC Atm	.120/.006	.104/.018	.279/.000		.094/.033	.107/.016
FC StudyF			.128/.004			
FC Relax			.102/.021			
FC Stmen						
FC Tcmen						
FC Studsup				-.138/.002	.103/.020	
OO spread		.116/.009	-.152/.001	-.192/.000		-.124/.005
OO Material	-.195/.000	-.395/.000	-.135/.002	-.190/.000		-.114/.010
OO Late						-.133/.003
OO Book						-.167/.000
OO Feedback						-.089/.045
OO Courses			-.363/.000			
OO Mandatory						
OO Relax	-.152/.001	-.129/.004		-.104/.020		

A6.9.2	Motivation and and perceptions of educational environment
Hypothesis	Higher scores on perceived quality of educational environment has a relation with motivation, intention and commitment.
Rationale	There is a lot of reason to believe that educational environment influences motivation, based on the interviews.
Test statistic	Spearman rankorder correlations.
Notes	There were no correlations between Job After and any of the education environment variables.
Conclusion	The correlations are few and small, with relatively high p-values. We reject that there is a relation between education environment and course, institutional and job motivation.

	Delft prior corr/ p-value	Delft now corr/ p-value	Delft after corr/ p-value	Course prior corr/ p-value	Course now corr/ p-value	Course after corr/ p-value	Job prior corr/ p-value	Job now corr/ p-value
TC Available							.120/.006	
TC Content					.149/.001			
TC Explain			.125/.004		.138/.002			
TC Master		.107/.015	.099/.024		.134/.002	.141/.001	.086/.048	.110/.012
TC Available					.091/.037	.089/.041		
TC Empathy					.098/.024		.095/.029	.096/.029
TC Enthusiasm	.097/.026		.142/.001		.107/.014	.119/.006		
TS Constr			.092/.036					
TS Feedback					.131/.003			
TS Repres						.133/.003		
TS Time				-.094/.033				
FC Atm	.163/.000	.227/.000			.142/.001			
FC Relax	.132/.003	.201/.000						
OO Book					.109/.014			
OO Courses		-.121/.006			-.170/.000			
OO Mandatory				.106/.018				.094/.038

A6.10 | Student disposition and student background variables

A6.10.1	Housing situation and membership fraternity
Hypothesis	Student attributes concerning housing and fraternity membership affect motivation, intention and confidence.
Rationale	A students' social environment affects motivation, intention and commitment.
Test statistic	Kruskal Wallis test.
Notes	Science orientation did not have any effect.
Conclusion	There are so few correlations, that we did not pursue analyses of these relations any further. We reject the hypothesis.

Variable	H	p-value
Housing situation		
Expec Interest	12.952	.005
Fraternity		
Expec BSA	5.851	.016
Imp P	5.516	.019
Delft prior	6.397	.011

A6.10.2	Total number of memberships, academic skills, aptitude, age, impairments, PR activies and commute time
Hypothesis	There is a relationship between aptitude, language skills, number of memberships, number of PR activities, impairments, and student disposition. Student attributes concerning prior education, language skills, membership and housing situation affect motivation, intention and commitment.
Rationale	Student attributes like social environment, prior education and language skills affect motivation, intention and commitment.
Test statistic	Spearman Rho Correlation.
Notes	Variables that did not show any correlations are not in cluded in the table.
Conclusion	Age did not correlate with any variables, nor did Expec Int. Job After did not correlate with any of the student attributes. Aptitude (grades for Maths and Physics) have a moderate effect on disposition. Interestingly enough, there are negative correlations between aptitude and Course Now and Delft Now. Number of membership shows some weak correlations with Delft motivation variables. The number of PR activities students participated in shows moderate correlations with course and institutional motivation. Impairment shows a moderate negative correlation with the expectation of obtaining the BSA. We accept that aptitude has a relation with disposition. We reject the other relations.

	Variable	Member-ship Total corr/ p-value	Skills Maths corr/ p-value	Skills Phyiscs corr/ p-value	Skills Comp corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Impair-ments corr/ p-value	PR Total corr/ p-value	Commute time corr/ p-value
1	Expec BSA	.118/ .005	.258/ 000	.176/ .000	.162/ .000	.122/ .004		.180/ .000	.165/ .000	-.146/ .001	.108/ .011	
2	Expec Difficulty		.152/ .000	.095/ .025				.184/ .000	.122/ .004			-.101/ .018
3	Imp P		.230/ .000	.136/ .001				.189/ .000	.202/ .000			
4	Imp Delft						.145/ .001					
5	Delft now								-.125/ .003			
6	Course prior										.185/ .000	
7	Course now							-.089/ .033	-.123/ .003		140/ .001	

	Variable	Membership Total corr/ p-value	Skills Maths corr/ p-value	Skills Phyiscs corr/ p-value	Skills Comp corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Impair= ments corr/ p-value	PR Total corr/ p-value	Commute time corr/ p-value
8	Course after	.121/ .004						.102/ .015			.146/ .000	
9	Delft prior	.106/ .012									.268/ .000	
10	Delft now	.113/ .007					-.091/ .031				.151/ .000	
11	Delft after	.097/ .020									.172/ .000	
12	Job prior						.101/ .016					.110/ .009
13	Job now	.139/ .001			.084/ .046							

A6.10.3	**Gender**
Hypothesis	Gender affect motivation, intention and commitment.
Rationale	Student attributes influence.
Test statistic	Spearman Rho Correlation analysis and Mann Whitney test for significance.
Notes	Variables that did not show any correlations are not included in the table.
Conclusion	There were no differences between men and women on Expec BSA, Expec Difficulty, Expec Interest, Importance Delft and on Importance P. Women score higher on motivation Course and Delft now, but considering the fact that women score differently on only two variables with weak strength, we reject the hypothesis.

	Variable	Median/mean men	Median/mean women	U	z	p-value	r
1	Course now	5.0/5.11	6.0/5.76	28240.000	-2.574	.010	0.11
2	Delft now	4.0/4.05	5.0/4.74	26584.500	-3.553	.000	0.15

A6.10.4	**Parental level of education, prior education and science orientation**
Hypothesis	Student attributes concerning parental level of education, prior education and science orientation affect motivation, intention and confidence.
Rationale	Student attributes like social environment, prior education and language skills affect motivation, intention and commitment.
Test statistic	Spearman Rho Correlation.
Notes	Science orientation did not have any effects.
Conclusion	There are so few correlations, that we did not pursue analyses of these relations any further. We reject the hypothesis.

Variable	H	p-value
Parental education		
Course prior	11.728	.003
Prior education		
Importance Delft	8.767	.012

A6.10.5	Grade retention					
Hypothesis	We expect that students who have been retained in a grade during their education career, will score differently on the disposition variables.					
Rationale	Students who have been retained, have failed academically at some point in their education careers.					
Test statistic	Mann Whitney test and biserial correlations for effect size.					
Conclusion	There is only one affected variable with a small effect size. Hypothesis rejected.					
Variable	Median/mean Not retained	Median/mean retained	U	z	p-value	r
1 Imp P	3.0/3.22	3.0/2.91	11687.000	-2.077	.038	.08

A6.10.7	Dispositions and success		
Hypothesis	There is a relationship between the number of credits obtained and student disposition variables		
Rationale	Success leads to more success, so there must be some relation between these variables.		
Statistic	Pearson correlation.		
Conclusion	The correlations between EC Total and Expec BSA, Expec Diff and Imp P are strong and have a low p-value. This outcome is not surprising, as students who had appropriate expectations of the level of the course or who find it easier than they expected, obtain more credits. Students who have the expectation to obtain positive advice on the BSA and who find obtaining the P-diploma more important, tend to obtain more credits.		
	Variable	Correlation coefficient	p-value
1	Expec BSA	.434	.000
2	Expec Diff	.379	.000
3	Expec Int	.025	.560
4	Imp Delft	-.051	.244
5	Imp P	.367	.000

A6.11 | Education environment and education attributes

A6.11.1	Educational attributes and perceptions of educational environment					
Hypothesis	Attributes of a course have effect on how students perceive the quality of the educational environment.					
Rationale	We assume that an overloaded curriculum, number of exams and education where presence is mandatory, puts a lot of strain on the students and this is reflected in a lower student perception of the quality of the environment. We also assume that number of hours with Participatory education activities and lectures will have a positive effect on the perception of educational environment.					
Test statistic	Spearman correlations.					
Conclusion	There is a cluster of negatively correlated variables pertaining to perceptions of teachers for participatory activities, but these correlations are small and have large p-values. Apart from these relations, there does not seem to be any clear pattern in the correlations that were found.					
	EC Variable	N Participatory corr/ p-value	N Lectures corr/ p-value	N Mandatory corr/ p-value	N Exams corr/ p-value	N Courses corr/ p-value
1	TC Content	-.099/.028			.122/.006	
2	TC Explain	-.091/.042			.095/.034	
3	TC Hall	-.105/.019			.091/.042	-.102/.023
4	TC Master	-.102/.023		.101/.024	.139/.002	
5	TC Available		-.104/.021	.147/.001	.214/.000	
6	TC Empathize	-.104/.021				-.102/.023
7	TC Enthusiasm	-.151/.001	.134/.003			-.174/.000
8	TS Project			-.185/.000		
9	TS Constructive			-.162/.000		
10	TS Transparent	.101/.026	-.112/.014			

	EC Variable	N Participatory corr/ p-value	N Lectures corr/ p-value	N Mandatory corr/ p-value	N Exams corr/ p-value	N Courses corr/ p-value
11	TS Feedback			-.120/.008		
12	TS Level	-.120/.008			.113/.013	
13	TS Repres				.130/.004	
14	TS Time	.100/.028	-.119/.009	-.101/.027		.120/.008
15	FC Atmosphere	.116/.011		-.104/.022	-.115/.011	
16	FC Study Faculty		-.138/.002			.130/.004
17	FC Relax	.142/.002	-.156/.001	-.166/.000		
18	FC Student mentor					-.098/.031
19	FC Teacher mentor		-.142/.002			.105/.021
20	OO Spread		-.120/.009			.140/.002
21	OO Material	-.149/.001	.199/.000			-.127/.006
22	OO Late			-.133/.005		
23	OO Book		-.097/.038	-.099/.035		
24	OO Feedback		.139/.003		-.131/.006	-.093/.049
25	OO Courses	-.123/.009			.101/.031	
26	OO Mandatory	.161/.001			-.178/.000	-.165/.000
27	OO Relax	.209/.000			-.159/.001	

A6.12 | Education environment and student background variables

A6.12.1	Housing situation
Hypothesis	Housing situation correlates with perception of quality of educational environment.
Rationale	Students who live independently relate to their environment differently than students who live with their parents.
Test statistic	Mann Whitney.
Notes	Number of students who live at home n=230 and number of students who live independently n=225, student housing n=144.
Conclusion	We do not reject the hypothesis because there is consistency in the outcomes of the two analyses. These effects should be explored in the model.

	Variable	Median/mean no member	Median/mean member	U	z	p-value	r
Parental v independent housing							
TC	Empathize	3.0/3.08	3.0/2.92	19384.000	-2.226	.026	0.11
TS	Feedback	3.0/2.82	3.0/2.65	18732.500	-1.962	.050	0.10
FC	Studsup	4.0/3.07	4.0/3.48	18392.000	-1.956	.051	0.10
OO	Feedback	2.0/2.44	3.0/2.63	17706.500	-2.303	.021	0.11
OO	Courses	2.0/2.30	2.0/2.54	17883.000	-2.238	.025	0.11
OO	Mandatory	2.0/2.29	2.0/2.56	16319.500	-3.460	.001	0.17
Parental v student housing							
TC	Empathize	3.0/3.08	3.0/2.89	11945.500	-2.450	.014	0.13
TS	Feedback	3.0/2.82	3.0/2.53	11340.000	-2.134	.033	0.12
FC	Studsup	4.0/3.07	4.0/3.48	10992.500	-2.265	.024	0.12
OO	Mandatory	2.0/2.29	2.0/2.53	10274.500	-2.824	.005	0.16

A6.12.2	Membership
Hypothesis	Membership of a non-course related association affects student behaviour.
Rationale	Students who are members of associations have more opportunities to learn about ways to negotiate their way through university. We expect to find differences between members and non members.
Test statistic	Mann Whitney.
Notes	Non course related Delft: non-member n=244, member n=281. Course and non-course related association in Delft. Non-member n=120, member n=379 Membership Total: Non-members n=125, members n=399. All variables with small p-values also have an effect size that falls within our minimum scores.
Conclusion	For non course related associations there are differences between TC Explain, TS Repres and OO Late. For all Delft associations there are differences between TC Explain, FC Relax, FC Student Mentor and OO Relax. Tot all memberships there are differences for FC Relax and OO Relax. Non-members find it harder to have enough time for relaxation.

	Variable	Median/mean no member	Median/mean member	U	z	p-value	r
Non-course related associations in Delft							
1	TC Explain	3.0/3.36	3.0/3.14	29201.500	-3.174	.002	0.14
2	TS Trans	4.0/3.39	3.0/3.20	29590.500	-2.104	.035	0.09
3	TS Feedback	3.0/2.88	3.0/2.66	29666.500	-2.038	.042	0.09
4	TS Repres	4.0/3.50	3.0/3.33	28813.000	-2.652	.008	0.12
5	OO Late	2.0/2.43	3.0/2.54	28247.000	-2.412	.016	0.11
Course and non-course related associations in Delft							
1	TC Explain	3.0/3.41	3.0/3.19	21199.500	-2.873	.004	0.13
2	FC Study Campus	4.0/3.15	4.0/3.50	21277.500	-2.018	.044	0.09
3	FC Relax	3.0/3.03	4.0/3.37	21033.000	-2.174	.030	0.10
4	FC Student mentor	3.0/2.93	4.0/3.36	20324.00	-2.694	.007	0.12
5	OO Relax	3.0/3.08	3.0/2.83	19015.500	-2.864	.004	0.13

A6.12.3	Total number of memberships, academic skills, aptitude, age, impairments, PR activies and commute time
Hypothesis	There is a relationship between student attributes and students' perceptions of the education environment.
Statistic	Spearman rank order correlation.
Notes	Age did not show a single correlation and is not included in the table below.
Conclusion	There are relations between maths, physics, and computer skills and aptitude, and perceptions of the education environment. We reject that there are relations between perceptions of education environment and the other student attributes.

	Variable	Membership total corr/ p-value	Skills Maths corr/ p-value	Skills Physics corr/ p-value	Skills Comp corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Impairment Total corr/ p-value	PR Total corr/ p-value	Commute time corr/ p-value
1	TC Content		.137/ 002									
2	TC Explain	-.105/ 016										
3	TC Hall		.122/ 005	.103/ 018				.145/ 001	.094/ 031			
4	TC Master			.133/ 002								

	Variable	Membership total corr/ p-value	Skills Maths corr/ p-value	Skills Physics corr/ p-value	Skills Comp corr/ p-value	Lang Dutch corr/ p-value	Lang English corr/ p-value	SE Maths corr/ p-value	SE Physics corr/ p-value	Impairment Total corr/ p-value	PR Total corr/ p-value	Commute time corr/ p-value
5	TC Available		.174/ 000	.124/ 004	.092/ 035			.106/ 015				
6	TC Empathy									-.099/ 024		
7	TS Consist		-.123/ 005			-.092/ 038		-.110/ 013	-.089/ 044			
8	TS Trans							-.088/ 045	-.093/ 036			
9	TS Exp		.187/ 000		.097/ 027			.164/ 000	.162/ 000			
10	TS Level		.182/ 000	.117/ 008	.146/ 001			.112/ 011	.137/ 002			
11	TS Repres		.182/ 000	.143/ 001	.144/ 001					-.097/ 027		
12	TS Time		.097/ 027					.105/ 018			.092/ 037	-.097/ 028
13	FC Atm										.097/ 029	
14	FC Relax			-.102/ 021				- .128/ 004	-.106/ 017			
15	FC Study C											-.088/ 047
16	FC Stmen			.096/ 031								
17	FC Tcmen			-.091/ 040								
18	FC Studsup									.134/ 002		
19	OO spread		-.114/ 010					-.091/ 043		.121/ 007		
20	OO Material		-.258/ 000	-.155/ 000		-.132/ 003		-.130/ 004	-.140/ 002			.144/ 001
21	OO Late			-.096/ 031								
22	OO Book		-.108/ 015							.105/ 021		
23	OO Feedback				-.092/ 038							
24	OO Courses										-.097/ 032	
25	OO Mandatory			.133/ 003		.167/ 000	.147/ 001					-.089/ 049
26	OO Relax	-.129/ 004	-.131/ 003		.134/ 003	-.093/ 040		-.132/ 004	-.135/ 003	.186/ 000		.126/ 005

A6.12.4	Gender
Hypothesis	Gender affects the scores on perceived quality of teacher and facility quality.
Rationale	We expect to find differences between male and female students in their percpetions of the education environment.
Test statistic	Mann Whitney.
Notes	Women score significantly different on TC and FC. Women score lower than men on TC, while they score higher on OO. This indicates that women perceive lower quality with the teachers and in educational organization.
Conclusion	Gender affects the perceptions of the education environment.

	Variable	Median/mean men	Median/mean women	U	z	p-value	r
1	TC Explain	4.0/3.49	3.0/3.14	25270.500	-2.100	.036	0.09
2	TC Hall	4.0/3.75	4.0/3.47	23323.000	-3.449	.001	0.15
3	TC Master	4.0/3.99	4.0/3.79	23849.500	-3.102	.002	0.14
4	TC Available	4.0/3.68	3.0/3.35	22722.000	-3.833	.000	0.17
5	TC Empathy	3.0/3.06	3.0/2.80	23416.500	-3.394	.001	0.15
6	TS Expectation	4.0/3.47	3.0/3.30	24027.500	-2.127	.033	0.10
7	TS Level	4.0/3.38	3.0/3.04	21088.500	-4.172	.000	0.19
8	TS Representation	4.0/3.47	3.0/3.28	23696.000	-2.367	.018	0.11
9	FC Atmosphere	4.0/3.82	4.0/4.12	21595.000	-3.852	.000	0.17
10	FC Relax	3.0/3.19	4.0/3.52	22775.000	-2.825	.005	0.13
11	OO Spread	3.0/2.94	3.0/3.11	23168.500	-2.105	.035	0.09
12	OO Late	2.0/2.43	3.0/2.61	23081.000	-2.264	.024	0.10
13	OO Feedback	3.0/2.48	3.0/2.70	23002.000	-2.235	.025	0.10
14	OO Courses	2.0/2.45	2.0/2.26	22293.500	-2.783	.004	0.13
15	OO Relax	2.0/2.74	3.0/3.05	20773.000	-3.422	.001	0.16

A6.12.5	Parental level of education, prior education and science orientation
Hypothesis	Student attributes concerning parental level of education, prior education, science orientation affect perceptions of the education environment.
Rationale	Student attributes are expected to have a relationship with how students perceive their environment.
Test statistic	Kruskal Wallis and Mann Whtiney tests.
Notes	Fraternity membership did not have any effects and is not included in this table. As parental education only affected one variable, we did not test any further. Science orientation (SO) has three categories: 1 = intrinsically motivated, 2 = externally motivated, 3 = idealistically motivated. Prior education profiles: S&T = Science and Technology, S&H = Science and Health, S&T/S&H = combined profile.
Conclusion	We reject that fraternity and parental level of education influence the students' perceptions of the education environment. In case of parental education level the Mann Whitney post hoc tests did not bring out any significant differences. Prior education influences how students perceive the exams and assessment in the courses. Science orientation has a minor influence on how students perceive the education organisation of their course.

Variable	H	p-value
Education level parents		
TS Repres	7.635	.022
Science orientation (SO)		
TC Enthusiasm	6.033	.049

Variable	H	p-value
TC Master	9.670	.008
TS Level	13.795	.001
TS Repres	14.902	.001
OO Book	6.049	.049
Prior education		
TS Level	24.150	.000
TS Repres	7.453	.024
FC Atm	8.353	.015
FC Stud sup	8.232	.016
OO Courses	14.393	.001
OO Relax	6.188	.045

Variable	Median/mean no member	Median/mean member	U	z	p-value	r
TC Enthusiasm						
SO1 and SO2	4.00/3.96	4.00/3.79	19974.500	-2.247	.025	0.11
TC Hall						
SO1 and SO2	4.00/3.76	4.00/3.48	19804.000	-2.365	.018	0.11
TC Master						
SO1 and SO2	4.00/4.00	4.00/3.74	18942.000	-3.111	.002	0.15
TS Level						
SO1 and SO2	4.00/3.35	3.00/3.02	17465.000	-3.691	.000	0.18
S&T and S&H	4.00/3.38	3.00/2.75	8286.500	-4.579	.000	0.26
S&H and S&T/S&H	3.00/2.75	3.00/3.20	6382.500	-4.110	.000	0.25
TS Repres						
Ed parents 1 and 2	4.0/3.56	3.0/3.32	13989.000	-2.791	.005	0.14
SO1 and SO2	4.00/3.51	3.00/3.16	17439.500	-3.752	.000	0.18
SO2 and SO3	3.00/3.16	4.00/3.49	5264.500	-2.451	.014	0.16
S&T and S&H	4.00/3.50	3.00/3.26	9940.500	-2.403	.016	0.13
S&H and S&T/S&H	3.00/3.26	4.00/3.51	7393.500	-2.450	.014	0.15
OO Book						
SO1 and SO2	1.00/1.22	1.00/1.35	17513.000	-2.446	.014	0.12
OO Courses						
S&T and S&H	1.00/1.55	1.00/1.32	8176.500	-3.373	.001	0.20
S&H and S&T/S&H	1.00/1.32	1.00/1.58	5930.000	-3.513	.000	0.22
OO Relax						
S&T and S&H	2.00/1.87	2.00/2.05	9191.000	-1.969	.049	0.11
S&H and S&T/S&H	2.00/2.05	2.00/1.80	6575.000	-2.400	.016	0.15
FC Atm						
S&T and S&H	4.00/3.93	4.00/4.09	10105.500	-2.178	.029	0.12
S&H and S&T/S&H	4.00/4.09	4.00/3.80	7203.500	-2.753	.006	0.17
FC Studsup						
S&T and S&H	4.00/3.11	4.00/3.64	9692.500	-2.598	.009	0.15
S&H and S&T/S&H	4.00/3.64	4.00/3.13	7252.500	-2.533	.011	0.16

A6.12.6	Grade retention
Hypothesis	Grade retained students will have different perceptions of their education environment than students who have not been retained in a grade at some point in their education careers.
Rationale	Students who have been retained in a grade, have dealth with academic failure at some point in their lives. We expect this to have an effect on their experiences in their education environment.
Test statistic	Mann Whitney test and biserial correlation for effect size.
Conclusion	Grade retention only affects one education environment variable and the effect is weak. Hypothesis rejected.

Variable	Median/mean Not retained	Median/mean Retained	U	z	p-value	r
1 TS Exp	3.0/3.29	3.0/3.04	9769.000	-2.760	.006	.12

Appendix 7 | Course effects in cohort 2010 and 2009

A7.1 | Course effects for Cohort 2010

A7.1.1	Course 'box' effects on Student Behaviour
Hypothesis	There are effects of course on student behaviour.
Rationale	Students self select for courses and courses have different attributes. We would expect course effects on student behaviour. This hypothesis is based on interview data: students seem to observe notable differences between behaviour of students from different courses that are sometimes considered to be related to requirements of the courses. We used the clustering of courses in 'boxes' as is common in DUT.
Test statistic	Kruskall Wallis test, Mann Whitney tests for post hoc with Bonferroni correction.
Notes	There is only one correlation smaller than .001, which is Check. This variable does not correlate with the output variable in the model. Enough is the only other variable with a small p-value and the post hoc tests show that the design box is deviant from the other boxes.
Conclusion	We conclude that there are only differences between the boxes for check and enough.

	Variable	H	p-value
1	Check	24.678	.000
2	Eff	7.135	.028
3	Enough	11.774	.003
4	Forget	6.718	.035
5	Help	6.422	.040
6	Mark	7.321	.026
7	Toomuch	6.479	.039

Variable	Median/mean	Median/mean	U	z	p-value	r
Check						
Engineering and Science	4.0/3.64	4.0/3.99	9499.000	-2.653	.008	.14
Engineering and Design	4.0/3.64	4.0/4.10	17476.500	-4.726	.000	.22
Eff						
Engineering and Science	3.0/3.16	3.0/2.86	9799.500	-2.269	.023	.12
Science and Design	3.0/2.86	3.0/3.24	5171.000	-2.604	.009	.17
Enough						
Engineering and Design	3.0/3.27	4.0/3.63	19251.000	-3.251	.001	.15
Science and Design	3.0/3.26	4.0/3.63	5222.000	-2.477	.013	.16
Forget						
Science and Design	4.0/3.60	3.0/3.34	5279.000	-2.429	.015	.16
Help						
Engineering and Design	4.0/3.45	4.0/3.68	20353.000	-2.503	.012	.12
Mark						
Engineering and Design	3.0/2.78	3.0/3.07	20002.500	-2.661	.008	.13
Toomuch						
Engineering and Science	2.0/2.60	3.0/2.86	9945.500	-2.086	.037	.11
Science and Design	3.0/2.86	2.0/2.52	5224.000	-2.486	.013	.16

A7.1.2	Course 'box' effects on Student Disposition
Hypothesis	There are effects of course on student behaviour.
Rationale	Students self select for courses and courses have different attributes. We would expect course effects on student behaviour. This hypothesis is based on interview data: students seem to observe notable differences between behaviour of students from different courses that are sometimes considered to be related to requirements of the courses. We used the clustering of courses in 'boxes' as is common in DUT.
Test statistic	Kruskall Wallis test, Mann Whitney tests for post hoc with Bonferroni correction: the p-value cut off score for significance is .016.
Conclusion	Engineering and Design score significantly different on expectations difficulty and career perspective. We accept that there is a difference between the expectations students have of the difficulty of the course.

	Variable	H	p
1	Expec Difficulty	10.239	.006
2	Job after	15.759	.000

Variable	Median/mean	Median/mean	U	z	p-value	r
Expec Difficulty						
Engineering and Design	3.0/2.62	3.0/2.81	19697.000	-3.119	.002	.14
Science and Design	3.0/2.63	3.0/2.81	5476.000	-2.144	.032	.13
Job after						
Engineering and Design	3.0/2.80	2.0/2.32	18387.000	-3.926	.000	.18

A7.1.3	Course 'box' effects on Education environment
Hypothesis	There are effects of course on education environment.
Rationale	Students self select for courses and courses have different attributes. We would expect course effects on student behaviour. This hypothesis is based on interview data: students seem to observe notable differences between behaviour of students from different courses, that are sometimes considered to be related to requirements of the courses. We used the clustering of courses in 'boxes' as is common in DUT.
Test statistic	Kruskall Wallis test, Mann Whitney tests for post hoc with Bonferroni correction, which leads to a p-value of 0.017.
Conclusion	In most cases the design box is deviant from the other boxes: perceptions of teachers score lower in the design box, in general the design box scores lower on assessment and education organisation, but it scores higher on perceptions of the facilities.

	Variable	H	p
1	TC Available	18.493	.000
2	TC Content	13.289	.001
3	TC Empathize	9.694	.008
4	TC Explain	6.099	.047
5	TC Master	9.243	.010
6	TS Constr	9.912	.007
7	TS Exp	11.827	.003
8	TS Level	11.774	.003
9	TS Repres	15.418	.000
10	TS Time	22.458	.000
11	TS Trans	34.279	.000
12	FC Atmosphere	15.503	.000
13	FC Relax	6.750	.034
14	FC Stmen	18.150	.000
16	FC Studsup	13.944	.001
17	FC StudyC	6.924	.031
18	OO Book	31.312	.000
19	OO Spread	18.071	.000

Variable	Median/mean	Median/mean	U	z	p-value	r
TC Available						
Engineering and Science	4.0/3.80	4.0/3.90	10099.500	-1.986	.047	.10
Engineering and Design	4.0/3.80	4.0/3.49	19464.000	-3.239	.001	.15
Science and Design	4.0/3.90	4.0/3.49	4607.500	-3.851	.000	.25
TC Content						
Engineering and Design	4.0/3.69	4.0/3.43	19268.000	-3.533	.000	.16
Science and Design	4.0/3.75	4.0/3.43	5332.000	-2.412	.016	.15
TC Empathize						
Engineering and Design	3.0/3.29	4.0/3.43	19663.000	-3.029	.002	.14
Science and Design	3.0/3.25	4.0/3.43	5466.000	-2.046	.041	.13
TC Explain						
Engineering and Design	4.0/3.44	3.0/3.25	20406.500	-2.441	.015	.11
TC Master						
Engineering and Design	4.0/4.23	4.0/3.94	19272.000	-3.068	.002	.17
TS Constructive						
Engineering and Design	3.0/3.10	3.0/3.25	17631.500	-3.066	.002	.14
TS Expectations						
Engineering and Design	4.0/3.48	3.0/3.27	11754.000	-2.782	.005	.15
Science and Design	4.0/3.56	3.0/3.27	2769.000	-3.266	.001	.21
TS Level						
Engineering and Design	4.0/3.42	3.0/3.06	9388.000	-3.261	.001	.15
Science and Design	4.0/3.44	3.0/3.06	2407.000	-2.832	.005	.18
TS Representative						
Engineering and Design	4.0/3.64	3.0/3.25	9132.500	-3.504	.000	.16
Science and Design	4.0/3.67	3.0/3.25	2247.000	-3.524	.000	.23
TS Trans						
Engineering and Science	3.0/2.84	2.0/1.98	7118.000	-5.467	.000	.28
Science and Design	2.0/1.98	3.0/2.66	3736.500	-5.437	.000	.35
TS Time						
Engineering and Science	4.0/3.72	4.0/4.21	8758.000	-2.907	.004	.15
Engineering and Design	4.0/3.72	5.0/4.21	8193.000	-4.216	.000	.19
FC Atm						
Engineering and Design	4.0/3.93	4.0/4.08	18879.500	-3.921	.000	.18
FC Relax						
Engineering and Design	4.0/3.35	4.0/3.63	20477.000	-2.338	.019	.10
FC Stmen						
Engineering and Design	4.0/3.91	4.0/3.69	18989.500	-3.582	.000	.17
Science and Design	4.0/4.10	4.0/3.69	4743.500	-3.545	.000	.22
FC Tcmen						
Engineering and Design	3.0/2.58	3.0/2.65	18917.000	-3.504	.000	.16
Science and Design	3.0/2.08	3.0/2.65	4603.000	-3.749	.000	.24
FC Studsup						
Engineering and Science	3.0/2.51	4.0/3.35	8789.500	-3.488	.000	.17
Engineering and Design	3.0/2.51	4.0/3.05	20687.500	-2.132	.033	.09
FC StudyC						
Science and Design	4.0/3.88	4.0/3.44	5215.000	-2.536	.011	.16

Variable	Median/mean	Median/mean	U	z	p-value	r
OO Book						
Engineering and Design	4.0/3.37	4.0/3.26	17736.000	-4.834	.000	.22
Science and Design	4.0/3.58	4.0/3.26	4402.500	-4.405	.000	.28
OO Spread						
Engineering and Science	3.0/2.85	3.0/3.12	9849.500	-2.276	.023	.11
Engineering and Design	3.0/2.85	3.0/2.62	19915.500	-2.843	.004	.13
Science and Design	3.0/3.12	3.0/2.62	4515.500	-4.078	.000	.26

A7.1.4	Courses and educational environment		
Hypothesis	Courses score differently on the perceived quality of educational environment.		
Rationale	Faculties and courses are said to have different cultures and environment. We expect differences between the ‘boxes’: design, engineering and science.		
Test statistic	Kruskal-Wallis test.		
Conclusion	In general conclusions that are similar to the ones in Table A7.1.3 can be drawn based on this table. A number of courses seem to be deviant consistently, these are architecture and industrial design engineering, mechanical and maritime engineering, and applied earth sciences.		
	Variable	**H**	**p-value**
1	FC Atm	41.960	.000
2	FC Stmen	84.758	.000
3	FC Studsup	43.579	.000
4	FC StudyC	35.750	.000
5	FC StudyF	29.886	.003
6	FC Tcmen	75.553	.000
7	OO Book	87.751	.000
8	OO Feedback	22.880	.029
9	OO Late	31.414	.002
10	OO Spread	27.274	.007
11	TC Available	55.759	.000
12	TC Content	35.721	.000
13	TC Empathize	35.690	.000
14	TC Explain	28.233	.005
15	TC Hall	24.240	.019
16	TC Master	31.483	.002
17	TS Consistent	40.859	.000
18	TS Constructive	68.381	.000
19	TS Expectations	191.828	.000
20	TS Feedback	52.001	.000
21	TS Level	203.073	.000
22	TS Project	67.899	.000
23	TS Representative	238.324	.000
24	TS Time	270.665	.000
25	TS Trans	88.699	.000

	Variable	Courses	Mean difference	p-value
1	FC Atm	AE and ME	.510	.005
		ME and AR	-.569	.002
		ME and MAE	.604	.040
2	FC Relax	ME and AES	-1.320	.020
3	FC Stmen	AE and AR	.718	.001
		AE and PA	-.565	.021
		CE and EE	-.744	.002
		CE and PA	-.748	.001
		ME and EE	-.773	.003
		ME and PA	-.777	.002
		MAE and AM	3.063	.046
		AP and AR	.898	.007
		AM and EE	-3.409	.030
		AM and PA	-3.413	.030
		EE and IDE	.247	.015
		EE and AR	.171	.000
		IDE and PA	.245	.013
		IDE and AES	.274	.005
		AR and PA	.168	.000
		AR and AES	.208	.000
4	FC Studsup	AE and ME	1.110	.004
		CE and EE	-1.353	.007
		ME and CS	-1.699	.002
		ME and EE	-1.800	.000
		ME and AR	-1.043	.007
5	FC StudyC	MAE and AR	1.110	.017
		EE and AR	1.034	.033
6	FC StudyF	CE and AP	-.677	.014
		ME and AP	-.928	.000
		MAE and AP	-1.078	.045
		AP and AR	.852	.001
7	FC Tcmen	AE and CE	-.854	.031
		AE and AM	-1.680	.001
		AE and AR	-1.200	.000
		CE and EE	1.493	.033
		CE and PA	1.840	.023
		ME and AM	-2.000	.000
		ME and AR	-1.519	.000
		AP and AM	-1.931	.004
		AM and CS	2.211	.010
		AM and EE	2.320	.000
		AM and PA	2.667	.000
		EE and AR	-1.839	.002
		AR and PA	2.186	.003

	Variable	Courses	Mean difference	p-value
8	OO Book	AE and AR	.933	.000
		AE and AES	-.423	.013
		CE and EE	-.706	.001
		CE and AES	-.866	.000
		ME and AR	-.863	.000
		ME and AES	-.493	.002
		EE and AR	1.196	.000
		IDE and AR	.881	.005
		AR and AES	-1.356	.000
9	OO Courses	AE and AES	-.608	.000
		CE and AES	-.804	.000
		ME and AES	-.726	.000
		AR and AES	-.731	.000
10	OO Feedback	MAE and AR	.968	.031
		AM and AR	.952	.050
		EE and AR	1.057	.001
		IDE and AR	.827	.020
11	OO Late	AE and AES	-.680	.000
		CE and AES	-1.031	.000
		ME and AR	.622	.014
		ME and AES	-.589	.000
		MAE and AES	-.696	.016
		EE and AES	-.880	.003
		IDE and AES	-.725	.030
		AR and AES	-1.212	.000
12	OO Spread	ME and AR	.549	.050
13	TC Available	AE and AM	-.758	.037
		AE and IDE	.648	.002
		AE and AR	.568	.000
		CE and AM	-1.071	.001
		ME and AM	-1.232	.000
		AP and AM	-.911	.016
		AM and IDE	1.406	.000
		AM and AR	1.326	.000
		AM and PA	.869	.023
		EE and IDE	.665	.048
14	TC-Content	AE and AR	.406	.001
		CE and AES	-.323	.001
		ME and AES	-.481	.000
		AP and AES	-.500	.025
		EE and AR	.567	.028
		AR and AES	-.581	.000
		AR and AES	-.567	.000
15	TC Empathize	AE and IDE	.647	.000
		CE and IDE	.566	.013
		AM and IDE	1.121	.017

	Variable	Courses	Mean difference	p-value
16	TC Explain	ME and EE	-.594	.028
		EE and IDE	.652	.033
		EE and AR	.565	.041
17	TC Hall	AE and ME	.478	.004
18	TS Consist	AP and AR	-1.345	.030
19	TS Constr	CE and ME	.843	.000
		ME and IDE	-.948	.006
		ME and AR	-1.118	.000
		AP and AR	-1.397	.027
20	TS Exp	AE and CE	-.465	.025
		AE and ME	.518	.028
		AE and AR	2.297	.000
		CE and ME	.983	.000
		ME and MaE	-.931	.031
		ME and AR	1.779	.000
		ME and PA	-.820	.007
		MaE and AR	2.711	.000
		AP and AR	2.264	.000
		AM and AR	2.551	.010
		CS and AR	2.253	.000
		EE and AR	2.500	.000
		IDE and AR	2.153	.000
		AR and PA	-2.599	.000
21	TS Feedback	AE and AES	-1.536	.000
		CE and IDE	1.350	.001
		CE and AR	1.197	.000
		CE and AES	-.918	.000
		ME and AR	.879	.019
		ME and AES	-1.237	.000
		MAE and IDE	1.399	.022
		MAE and AR	1.246	.018
		AP and AES	-1.379	.022
		AM and IDE	1.824	.026
		AM and AR	1.671	.049
		IDE and AES	-2.268	.000
		AR and AES	-2.115	.000
		PA and AES	-1.810	.039
22	TS Level	AE and AR	2.709	.000
		CE and ME	.521	.023
		CE and AR	2.970	.000
		ME and AR	2.449	.000
		MAE and AR	2.969	.000
		AP and AR	2.559	.000
		AM and AR	2.873	.002
		CS and AR	2.580	.000
		EE and AR	2.779	.000

	Variable	Courses	Mean difference	p-value
		IDE and AR	2.342	.000
		AR and PA	-2.651	.000
		AR and AES	-3.484	.001
23	TS Proj	AE and CE	.805	.000
		AE and ME	.631	.007
		AE and EE	.792	.034
		CE and MAE	-1.376	.000
		CE and AR	-.513	.017
		ME and MAE	-1.202	.002
		MAE and EE	1.363	.001
		MAE and AR	1.112	.009
24	TS Repres	AE and MAE	-.456	.049
		AE and AR	2.934	.000
		CE and IDE	.678	.003
		CE and AR	3.122	.000
		ME and MAE	-.636	.006
		ME and AR	2.754	.000
		MAE and IDE	.946	.000
		MAE and AR	3.390	.000
		AP and AR	2.794	.000
		AM and AR	3.346	.000
		CS and AR	2.820	.000
		EE and AR	3.231	.000
		IDE and AR	2.444	.000
		IDE and PA	-.902	.000
		AR and PA	-3.346	.000
		AR and AES	-3.346	.000
25	TS Time	AE and CE	-.627	.001
		AE and MAE	-.692	.016
		AE and IDE	-1.035	.000
		AE and AR	2.882	.000
		AE and PA	-.950	.001
		CE and ME	.943	.000
		CE and AR	3.509	.000
		ME and MAE	-1.007	.000
		ME and IDE	-1.350	.000
		ME and AR	2.566	.000
		ME and PA	-1.266	.000
		MAE and AR	3.573	.000
		AP and AR	3.080	.000
		AM and AR	3.134	.000
		CS and AR	3.251	.000
		EE and AR	3.471	.000
		IDE and AR	3.917	.000
		AR and PA	-3.832	.000
		AR and AES	-3.689	.000

	Variable	Courses	Mean difference	p-value
26	TS Trans	AE and ME	-.876	.029
		AE and IDE	-1.223	.001
		AE and AR	-.870	.022
		AE and PA	1.502	.008
		CE and PA	2.194	.000
		ME and AP	1.437	.011
		ME and EE	1.592	.023
		ME and PA	2.378	.000
		MAE and AP	1.997	.006
		MAE and AM	2.874	.021
		MAE and EE	2.152	.007
		MAE and PA	2.938	.000
		PA and IDE	-1.784	.001
		PA and AR	-1.431	.010
		AM and IDE	-2.261	.045
		EE and IDE	-1.939	.003
		EE and AR	-1.587	.023
		IDE and PA	2.725	.000
		AR and PA	2.372	.000

A7.1.5	Course 'box' effects on Student Attributes
Hypothesis	There are effects of course on student behaviour.
Rationale	Students self select for courses and courses have different attributes. We would expect course effects on student attributes. We test for differences in age, number of PR activities students participated in, self reported language skills and number of association memberships.
Test statistic	Kruskall Wallis test and Mann Whitney test as post hoc test.
Conclusion	Students in the design box are older on average than students from the other boxes. Students in the design boxes score lower on academic skills.

	Variable	H	p
1	Age	13.234	.001
2	Skills Maths	27.098	.000
3	Skills Physics	35.929	.000
4	Skills Computer	25.809	.000

Variable	Mean	Mean	U	z	p-value	r
Age						
Engineering and Design	18.6	19.1	18844.500	-3.445	.001	.16
Science and Design	18.8	19.1	5107.500	-2.615	.009	.16
Skills Maths						
Engineering and Science	4.0/3.70	4.0/3.96	9705.000	-2.484	.013	.13
Engineering and Design	4.0/3.70	3.0/3.42	18961.500	-3.603	.000	.16
Science and Design	4.0/3.96	3.0/3.42	4045.500	-5.096	.000	.32
Skills Physics						
Engineering and Design	4.0/3.78	3.0/3.42	16596.500	-5.822	.000	.27
Science and Design	4.0/3.81	3.0/3.42	4593.000	-3.969	.000	.25
Skills Computer						
Engineering and Design	3.0/3.11	3.0/2.68	17900.000	-4.347	.000	.20
Science and Design	3.0/3.29	3.0/2.68	4334.500	-4.315	.000	.27

A7.1.6	Course 'box' effects on Education Attributes
Hypothesis	Courses are structured and organised differently.
Rationale	The foci of the courses are different and as a result we would expect different course attributes.
Test statistic	ANOVA with Bonferroni post hoc test.
Notes	
Conclusion	The engineering and sciences boxes have fewer participatory learning activities than design, but they have significantly more mandatory activities and more exams.

	Variable	F	Degrees of freedom model/residual	p-value	r
1	N Participatory	83.720	2/529	.000	.49
2	N Courses	1.481	2/529	.228	NA
3	N Exams	107.187	2/259	.000	.53
4	N Lectures	2.117	2/259	.121	NA
5	N Mandatory	152.200	2/259	.000	.60

Variable	Mean difference	p-value
N Participatory		
Engineering and Science	-55.69	.000
Engineering and Design	-115.48	.000
Science and Design	-59.79	.000
N Exams		
Engineering and Design	4.25	.000
Science and Design	3.74	.000
N Mandatory		
Engineering and Science	109.15	.000
Engineering and Design	146.28	.000
Science and Design	37.13	.008

A7.2 | Course effects for Cohort 2009

A7.2.1	**Course 'box' effects on Student Behaviour**
Hypothesis	There are effects of course on student behaviour.
Rationale	Students self select for courses and courses have different attributes. We would expect course effects on student behaviour. This hypothesis is based on interview data: students seem to observe notable differences between behaviour of students from different courses, that are sometimes considered to be related to requirements of the courses. We used the clustering of courses in 'boxes' as is common in DUT.
Test statistic	Kruskall Wallis test, Mann Whitney tests for post hoc with Bonferroni correction with a cut off score of .016.
Conclusion	We conclude that there are differences between the boxes for behind, bursts, eff, enough, hard, tempo and toomuch. These variables did not show any effects in the 2010 cohort. Therefore we conclude that the behavioural variables are specific to populations.

	Variable	**H**	**p**
1	Behind	28.064	.000
2	Bursts	7.646	.022
3	Eff	7.613	.022
4	Enough	24.098	.000
5	Hard	21.127	.000
6	Tempo	13.560	.001
7	Toomuch	10.267	.006

	Variable	**Median/mean**	**Median/mean**	**U**	**z**	**p-value**	**r**
Behind							
1	Engineering and Design	3.0/2.79	3.0/3.31	13432.500	-5.449	.000	.27
2	Science and Design	3.0/3.01	3.0/3.31	5792.500	-1.981	.048	.12
Bursts							
1	Engineering and Design	2.0/2.70	3.0/2.98	16297.500	-2.776	.006	.14
Eff							
1	Engineering and Science	3.0/3.26	3.0/2.90	6161.500	-2.409	.016	.14
2	Science and Design	3.0/2.90	3.5/3.29	5444.000	-2.684	.007	.16
Enough							
1	Engineering and Design	3.0/3.22	4.0/3.70	14007.000	-4.870	.000	.24
2	Science and Design	3.0/3.27	4.0/3.70	5401.5000	-2.722	.006	.17
Hard							
1	Engineering and Design	3.0/2.93	3.0/3.38	14344.500	-4.559	.000	.22
2	Science and Design	3.0/3.04	3.0/3.38	5582.000	-2.385	.017	.14
Tempo							
1	Engineering and Design	3.0/3.20	4.0/3.52	15549.000	-3.516	.000	.17
Toomuch							
1	Engineering and Science	2.0/2.41	3.0/2.82	5763.000	-3.077	.002	.18
2	Science and Design	3.0/2.82	2.0/2.42	5319.000	-2.848	.004	.17

A7.2.2	Course 'box' effects on Student Disposition
Hypothesis	There are effects of course on student behaviour.
Rationale	Students self select for courses and courses have different attributes. We would expect course effects on student behaviour. This hypothesis is based on interview data: students seem to observe notable differences between behaviour of students from different courses, that are sometimes considered to be related to requirements of the courses. We used the clustering of courses in 'boxes' as is common in DUT.
Test statistic	Kruskall Wallis test, Mann Whitney tests for post hoc with Bonferroni correction.
Conclusion	Engineering and Design score significantly different on expectations difficulty and career perspective. We accept that the boxes differ regarding the students' expectations of the difficulty of the course.

	Variable	H	p
1	Expec BSA	14.081	.001
2	Expec Difficulty	26.124	.000
3	Expec Interest	20.756	.000
4	Delft now	12.962	.002
5	Course after	10.286	.006
6	Job prior	9.201	.010
7	Skills Maths	34.198	.000
8	Skills Physics	38.535	.000
9	Skills Computer	38.657	.000

Variable	Median/mean	Median/mean	U	z	p-value	r
Expec BSA						
Engineering and Science	4.0/4.22	5.0/4.51	7680.000	-2.959	.003	.16
Engineering and Design	4.0/4.22	5.0/4.48	20596.000	-3.122	.002	.14
Expec Difficulty						
Engineering and Design	3.0/2.65	3.0/3.02	18112.500	-5.152	.000	.24
Science and Design	3.0/2.77	3.0/3.02	7274.000	-2.507	.012	.14
Expec Interest						
Engineering and Science	3.0/3.05	3.0/3.45	6928.500	-4.114	.000	.23
Engineering and Design	3.0/3.05	3.0/3.29	20324.000	-3.369	.001	.15
Delft now						
Engineering and Design	5.0/4.17	5.0/4.78	21864.500	-2.790	.005	.13
Science and Design	4.0/3.95	5.0/4.78	6944.000	-3.247	.001	.18
Course after						
Engineering and Design	1.0/2.04	1.0/1.57	22383.000	-2.459	.014	.11
Science and Design	2.0/2.20	1.0/1.57	7213.500	-2.896	.004	.16
Job prior						
Engineering and Design	2.0/1.97	1.0/1.59	21971.500	-2.758	.006	.12
Science and Design	2.0/1.96	1.0/1.59	7649.000	-2.234	.025	.12
Skills Maths						
Engineering and Science	4.0/3.77	4.0/4.00	8365.000	-2.371	.018	.13
Engineering and Design	4.0/3.77	3.5/3.47	20381.500	-4.137	.000	.19
Science and Design	4.0/4.00	3.5/3.47	5733.500	-5.417	.000	.31
Skills Physics						
Engineering and Design	4.0/4.41	3.0/3.44	18151.500	-6.005	.000	.28
Science and Design	4.0/3.80	3.0/3.44	6786.000	-3.775	.000	.21
Skills Computer						
Engineering and Science	3.0/2.99	4.0/3.66	6635.000	-4.699	.000	.26
Engineering and Design	3.0/2.99	3.0/2.80	22816.500	-2.170	.030	.10
Science and Design	4.0/3.66	3.0/2.80	5090.000	-6.202	.000	.35

A7.2.3	Course 'box' effects on Education environment
Hypothesis	There are effects of course on education environment.
Rationale	Students self select for courses and courses have different attributes. We would expect course effects on student behaviour. This hypothesis is based on interview data: students seem to observe notable differences between behaviour of students from different courses, that are sometimes considered to be related to requirements of the courses. We used the clustering of courses in 'boxes' as is common in DUT.
Test statistic	Kruskall Wallis test, Mann Whitney tests for post hoc with Bonferroni correction, which leads to a p-value of 0.017.
Conclusion	In most cases the design box is deviant from the other boxes: perceptions of teachers score lower in the design box, in general the design box scores lower on assessment and education organisation, but it scores higher on perceptions of the facilities. This outcome is similar to the outcome of cohort 2010.

	Variable	H	p
1	TC Available	40.752	.000
2	TC Content	14.686	.001
3	TC Empathize	7.887	.019
4	TC Explain	7.184	.028
5	TC Hall	18.283	.000
6	TC Master	30.569	.000
7	TS Constr	9.765	.008
8	TS Exp	9.709	.008
9	TS Level	38.108	.000
10	TS Project	18.987	.000
11	TS Repres	41.677	.000
12	TS Time	19.786	.000
13	TS Trans	14.487	.001
14	FC Atmosphere	26.849	.000
15	FC Relax	35.248	.000
16	FC StudyF	11.445	.003
17	OO Book	11.289	.004
18	OO Courses	14.864	.001
19	OO Feedback	9.955	.007
20	OO Late	7.430	.024
21	OO Material	16.484	.000
22	OO Relax	15.049	.001
23	OO Spread	13.309	.001

Variable	Median/mean	Median/mean	U	z	p-value	r
TC Available						
Engineering and Design	4.0/3.73	3.0/3.33	15913.500	-5.266	.000	.28
Science and Design	4.0/3.96	3.0/3.33	4911.500	-5.161	.000	.33
TC Content						
Engineering and Design	4.0/3.49	3.0/3.32	18761.500	-2.905	.004	.15
Science and Design	4.0/3.67	3.0/3.32	6026.500	-3.340	.001	.21
TC Empathize						
Engineering and Design	3.0/3.02	3.0/2.83	19369.000	-2.316	.021	.12
Science and Design	3.0/3.11	3.0/2.83	6565.500	-2.335	.020	.15
TC Enthusiasm						
Science and Design	4.0/4.05	4.0/3.80	6628.500	-2.083	.037	.13

Variable	Median/mean	Median/mean	U	z	p-value	r
TC Explain						
Science and Design	4.0/3.43	3.0/3.15	6460.500	-2.526	.012	.16
TC Hall						
Engineering and Design	4.0/3.72	4.0/3.50	18404.500	-3.138	.002	.17
Science and Design	4.0/3.90	4.0/3.50	5703.000	-3.827	.000	.25
TC Master						
Engineering and Design	4.0/4.03	4.0/3.69	16377.500	-4.926	.000	.26
Science and Design	4.0/4.13	4.0/3.69	5532.000	-4.196	.000	.27
TS Constr						
Engineering and Science	3.0/3.02	3.0/3.33	6832.000	-2.482	.013	.16
Engineering and Design	3.0/3.02	3.0/3.33	17993.000	-2.650	.008	.14
TS Exp						
Engineering and Science	4.0/3.41	4.0/3.40	6849.500	-2.509	.012	.16
Science and Design	4.0/3.74	4.0/3.40	5766.500	-3.147	.002	.20
TS Feedback						
Engineering and Science	3.0/2.78	4.0/3.07	7039.000	-2.038	.042	.13
TS Level						
Engineering and Science	4.0/3.44	4.0/3.64	7105.500	-2.102	.036	.13
Engineering and Design	4.0/3.44	3.0/3.00	15386.500	-4.988	.000	.27
Science and Design	4.0/3.64	3.0/3.00	4641.500	-5.080	.000	.33
TS Project						
Engineering and Science	2.0/2.50	3.0/3.02	5876.500	-4.037	.000	.26
Engineering and Design	2.0/2.50	3.0/2.76	18032.500	-2.643	.008	.14
Science and Design	3.0/3.02	3.0/2.76	6120.000	-2.433	.015	.16
TS Repres						
Engineering and Science	4.0/3.55	4.0/3.84	6534.500	-3.114	.002	.20
Engineering and Design	4.0/3.55	3.0/3.15	15955.000	-4.526	.000	.24
Science and Design	4.0/3.84	3.0/3.15	4307.500	-5.739	.000	.37
TS Time						
Engineering and Design	4.0/3.84	4.0/4.18	15979.000	-4.431	.000	.24
TS Transparent						
Engineering and Science	3.0/3.11	4.0/3.48	6479.000	-3.049	.002	.20
Engineering and Design	3.0/3.11	4.0/3.49	17426.000	-3.157	.002	.17
FC Atmosphere						
Engineering and Design	4.0/3.75	4.0/4.17	15353.500	-5.105	.000	.27
Science and Design	4.0/3.75	4.0/4.17	5993.000	-2.734	.006	.17
FC Relax						
Engineering and Design	3.0/3.12	4.0/3.74	14173.000	-5.903	.000	.31
Science and Design	4.0/3.28	4.0/3.74	5960.000	-2.771	.006	.18
FC Study Facult						
Engineering and Science	3.0/2.87	4.0/3.34	6339.500	-3.201	.001	.21
Science and Design	4.0/3.34	3.0/2.95	5712.000	-3.069	.002	.20
FC Tcmen						
Engineering and Design	3.0/2.24	3.0/2.46	18290.500	-2.215	.027	.12

Variable	Median/mean	Median/mean	U	z	p-value	r
OO Feedback						
Engineering and Science	2.0/1.74	1.0/1.43	5314.500	-2.787	.005	.18
Science and Design	1.0/1.43	2.0/1.76	4992.500	-3.033	.002	.19
OO Book						
Engineering and Design	1.0/1.22	1.0/1.33	16902.000	-2.567	.010	.14
Science and Design	1.0/1.15	1.0/1.33	5102.500	-2.755	.006	.18
OO Courses						
Engineering and Design	2.0/1.62	1.0/1.38	14826.000	-3.829	.000	.20
Science and Design	1.0/1.43	1.0/1.38	5463.000	-1.962	.050	.13
OO Late						
Engineering and Design	1.0/1.64	2.0/1.65	16315.000	-2.137	.033	.11
Science and Design	1.0/1.49	2.0/1.65	5571.000	-2.371	.018	.15
OO Material						
Engineering and Design	2.0/1.96	2.0/1.64	15568.500	-4.029	.000	.22
OO Relax						
Engineering and Design	2.0/1.86	2.0/2.07	15862.500	-2.971	.003	.17
Science and Design	1.0/1.64	2.0/2.07	4788.500	-3.391	.001	.22
OO Spread						
Engineering and Science	2.0/2.06	2.0/1.77	6431.000	-2.244	.025	.14
Engineering and Design	2.0/2.06	2.0/2.20	17457.500	-1.984	.047	.10
Science and Design	2.0/1.77	2.0/2.20	5165.500	-3.516	.000	.23

A7.2.4	Course and educational environment
Hypothesis	Courses score differently on the perceived quality of educational environment.
Rationale	Faculties and courses are said to have different cultures and environments. We expect differences between the 'boxes': design, engineering and science.
Test statistic	Mann Whitney test.
Notes	We opted for ANOVA post hoc tests because the number of courses is quite large. Testing all the differences using MW tests would lead to alpha slippage. ANOVA is not the correct test for non-parametric data, but there are precedents for researchers taking Likert-scale scores as interval level. For the sake of exploration we use the ANOVA Bonferroni post hoc test. With 12 categories it is to be expected that nearly all tests are significantly different. We only give the exact course differences for the factor scores.
Conclusion	The post hoc tests show that not all courses differ significantly. In many cases it is Architecture and Industrial Design Engineering that are different from the other courses. There are differences between courses, but not between the boxes as such.

	Variable	H	p-value
1	TC Content	40.764	.000
2	TC Explain	270179	.002
3	TC Hall	46.866	.000
4	TC Master	39.250	.000
5	TC Available	63.735	.000
6	TC Empathize	47.861	.000
7	TC Enthusiasm	36.971	.000
8	TC Factor 1	66.090	.000
9	TC Factor 2	66.255	.000

	Variable		H	p-value
10	TS Proj		32.304	.000
11	TS Constr		20.584	.024
12	TS Consist		23.462	.009
13	TS Trans		27.187	.002
14	TS Exp		29.376	.001
15	TS Level		48.997	.000
16	TS Repres		53.486	.000
17	TS Time		37.295	.000
18	TS Factor 1		33.098	.000
19	TS Factor 2		33.198	.000
20	FC Atm		36.010	.000
21	FC StudyF		27.788	.002
22	FC Relax		62.301	.000
23	FC Stmen		51.193	.000
24	FC Tcmen		38.231	.000
25	FC Studsup		19.728	.032
26	FC Factor 1		20.239	.027
27	FC Factor 2		19.755	.032
28	OO Spread		30.386	.001
29	OO Material		35.967	.000
30	OO Late		44.914	.000
31	OO Book		40.216	.000
32	OO Feedback		36.148	.000
34	OO Mandatory		83.596	.000
35	OO Relax		60.107	.000
36	OO Factor 1		42.480	.000
37	OO Factor 2		36.500	.000
	Variable	**Courses**	**Mean difference**	**p-value**
1	TC Factor 1	AE and AR	1.945	.000
		CE and Maritime E	2.284	.030
		CE and IDE	1.601	.042
		CE and AR	2.421	.000
		Maritime E and EE	-2.916	.037
		CS and AR	2.386	.000
		EE and AR	3.053	.001
		PA and AR	1.786	.009
2	TC Factor 2	AE and IDE	1.190	.000
		AE and AR	1.213	.000
		CE and IDE	1.010	.009
		CE and AR	1.033	.001
		Phys and IDE	1.290	.017
		Phys and AR	1.313	.006
		CS and IDE	1.304	.002
		CS and AR	1.327	.000

	Variable	Courses	Mean difference	p-value
		EE and IDE	1.366	.043
		EE and AR	1.389	.020
		PA and AR	1.122	.001
		Mining E and IDE	1.633	.038
		Mining E and AR	1.656	.021
3	TS Factor 1	Mech E an CS	-2.355	.032
		Mech E and EE	-3.723	.002
		Mech E and AR	-1.761	.024
4	TS Factor 2	AE and EE	-3.716	.030
		EE and AR	-3.140	.024
5	FC Factor 1	No differences found in ANOVA Post Hoc test.		
6	FC Factor 2	AE and Mech E	2.095	.012
		CE and Mech E	2.023	.048
		Mech E and AR	-1.779	.037
		Mech E and PA	-2.525	.011
7	OO Factor 1	AE and AR	-1.496	.007
		CE and Phys	2.711	.001
		Phys and IDE	-2.655	.001
		Phys and AR	-2.731	.000
8	OO Factor 2	AE and CE	1.336	.008
		AE and Mech E	1.383	.001
		AE and PA	1.643	.001

A7.2.5	**Course ‘box’ effects on Student Attributes**
Hypothesis	There are effects of course on student behaviour.
Rationale	Students self select for courses and courses have different attributes. We would expect course effects on student attributes. We test for differences in age, number of PR activities students participated in, self reported language skills and number of association memberships.
Test statistic	Kruskall Wallis test and Mann Whitney test as post hoc test.
Conclusion	Students in the science box score higher on the self-ratings on English language skills.

Variable	**H**	**p**
Lang English	9.385	.009

Variable	**Median/mean**	**Median/mean**	**U**	**z**	**p-value**	**r**
Lang English						
Engineering and Science	4.0/3.88	4.0/4.11	8343.000	-2.332	.020	.15
Science and Design	4.0/4.11	4.0/3.75	7227.000	-2.981	.003	.19

A7.2.6	Course 'box' effects on Education Attributes				
Hypothesis	Courses are structured and organised differently.				
Rationale	Courses in the various boxes have different orientations and goals. We would expect that this leads to significant differences in course attributes.				
Test statistic	ANOVA with Bonferroni post hoc test.				
Conclusion	On all five course attributes studied here there are significant differences between the boxes.				
	Variable	**F**	**Degrees of freedom model/residual**	**p-value**	**r**
1	N Participatory	64.767	2/535	.000	.442
2	N Courses	3.065	2/535	.047	.106
3	N Exams	112.980	2/535	.000	.545
4	N Lectures	17.160	2/535	.000	.246
5	N Mandatory	178.094	2/535	.000	.632
	Variable			**Mean difference**	**p-value**
N Participatory					
1	Engineering and Science			-74.28	.000
2	Engineering and Design			-88.99	.000
3	Science and Design			-14.71	.559
N Lectures					
1	Engineering and Science			121.51	.000
2	Engineering and Design			57.67	.001
3	Science and Design			-63.84	.011
N Courses					
1	Engineering and Science			1.07	.495
2	Engineering and Design			1.37	.049
3	Science and Design			.30	1.00
N Exams					
1	Engineering and Science			1.06	.019
2	Engineering and Design			4.25	.000
3	Science and Design			3.19	.000
N Mandatory					
1	Engineering and Science			118.01	.000
2	Engineering and Design			157.96	.000
3	Science and Design			39.95	.002

Appendix 8 | Results of SEM testing sub structures of the model

To test the variables that were still left after the initial explorations that are presented in Appendices 7 and 8, we tested what happened if we used these variables in sub structures of the model using SEM. We discerned the student system that consisted of student attributes, disposition, behaviour and progress, and the education system, that consisted of education attributes, perceptions of education environment, behaviour and progress.

A8.1 | Education system

A8.1.1 | Cohort 2010

A8.1.1.1 | Education system with Education Attributes as manifest variables

The full education model consisted of the following relations:
Education Environment ← TC1, TC2, TS1, TS2, FC1, FC2, OO
Education Attributes = N Participatory, N Lectures, N Mandatory, N Exams, N Courses
Education Environment ← Education Attributes
Student Behaviour ← Education Environment
Student Behaviour ← Focus, DeepLearning, Load, Discipline
EC Total ← Student Behaviour

Note: The education environment variables are the weighted averages of the factors that emerged from the factor analyses reported in Appendices 7 and 8.
Note: The education attribute variables are manifest in this model.

A8.1.1.1 | Model 1

Full model SEM
Chi2=2034, df=113, p=.000
CFI=.301, RMSEA = .179
The manifest variables in the model all have a significant contribution to the latent variable that loads on these manifest variables.
The paths from N Lectures and N Mandatory to Ed Env are not significant in this model.
The paths from N Lectures, N Mandatory and N Participatory to Behaviour are not significant.

A8.1.1.1 | Model 2

Full model without N Lectures and N Mandatory

Chi2 = 911, df = 87, p=.000

CFI=.503, RMSEA=.134

The path from N Courses to Behaviour is not significant in this model.

Modification Indices show that model could be improved by adding a covariance path between N Exams and N Participatory. The MIs also show that the model would be improved by adding a covariance between the residue of Load and N Participatory. This shows that there is a relation between the residue of Load and the number of participatory teaching and learning activities; we are unsure what this relation is.

A8.1.1.1 | Model 3

The addition of the covariance between N Exams and N Participatory and the removal of the path between N Courses and Behaviour leads the following fit:

Chi2= 736, df=87, p=.000, CFI=.609, RMSEA=.119.

In this model the path from N Exams to Behaviour is not significant.

A8.1.1.1 | Model 4

The path from N Exams to Behaviour is removed.

Chi2=744, df=88, p=.000, CFI=.605, RMSEA=.119

The MIs also show that the model would be improved by adding a covariance between the residue of Load and N Participatory.

In this model the standardized effects are:

EC Total ← Behaviour =.506

EC Total ← Education Environment=.157

Behaviour ← Education Environment =.311

Education Environment ← NExams=.084

Education Environment ← NCourses=.079

Education Environment ← NParticipatory=.083

The effects of the education attributes on education environment are very small.

A8.1.1.2 | Education system with Education Attributes as latent variable

Education Environment ← TC1, TC2, TS1, TS2, FC1, FC2, OO

Education Attributes ← N Participatory, N Lectures, N Mandatory, N Exams, N Courses

Education Environment ← Education Attributes

Student Behaviour ← Education Environment

Student Behaviour ← Education Attributes

Student Behaviour ← Focus, DeepLearning, Load, discipline

EC Total ← Student Behaviour

A8.1.1.2 | Model 1

Full model SEM

Chi2=913, df=116, p=.000, CFI=.712, RMSEA=.114

The paths between Ed Env and Ed Attr and between Behaviour and Ed Attr are not significant in the model.

A8.1.2 | Cohort 2009

A8.1.2.1 | Education system with Education Attributes as manifest variables

The full model for 2009 had an extra Ed Env variable: OO2.

A8.1.2.1 | Model 1

Full model with added covariance between N Lectures and N Courses:

Chi2=1482, df=129, p=.000, CFI=.334, RMSEA=.146

All manifest variables loading onto the latent variables are significant in the model.

The paths from N Mandatory and N Participatory to Ed env are not significant in the model.

The paths from N Mandatory, N Lectures and N Exams to Behaviour are not significant in the model.

The Modification Indices show that adding a covariance path between N Courses and N Lectures would improve the model fit. So would adding paths between the residue of Discipline and N mandatory, between the residue of Focus and N Participatory, and between the residue of Deep Learning and N Participatory. This MIs show that there is a relation between these variables, but that these relations are not mediated by Behaviour.

Modification Indices show that the model could be improved if a path from Education Environment to EC Total would be added.

A8.1.2.1 | Model 2

Full model without N Mandatory and without paths from N Exams and N Lectures.

Chi2=1267, df=117, p=.000, CFI=.369, RMSEA=.141

The path from N Lectures to Ed Env is not significant in this model. The path from N Courses to Behaviour is not significant.

The MIs show that the model fit could be improved by adding a covariance term between N Lectures and N Courses. The MIs show that the model fit would be improved if a path was added from N Participatory to Ed Env. This is strange, as in model 1 this path was insignificant.

A8.1.2.1 | Model 3

Without N Lectures.

Chi2=1079, df=103, p=.000, CFI=.406, RMSEA=.139

All paths in the model are significant, but the model fit is very poor. There are no MIs that show any options to further improve the model.

In this model the standardized effects are:

EC Total ← Behaviour =.434

EC Total ← Education Environment=.118

Behaviour ← Education Environment=.287

Behaviour ← N Participatory=.339

Education Environment ← N Courses=-.260

Education Environment ← N Exams=.295

A8.1.2.2 Education system with Education Attributes as latent variable

Education Environment ← TC1, TC2, TS1, TS2, FC1, FC2, OO

Education Attributes ← N Participatory, N Lectures, N Mandatory, N Exams, N Courses

Education Environment ← Education Attributes

Student Behaviour ← Education Environment

Student Behaviour ← Education Attributes

Student Behaviour ← Focus, DeepLearning, Load, Discipline

EC Total ← Student Behaviour

A8.1.2.2 | Model 1

Full model SEM

Chi2=641, df=132, p-.000, CFI=.749, RMSEA=.089

The path from Ed Attributes to Behaviour is not significant.

A8.1.2.2 | Model 2

Without a path from Ed Attributes to Behaviour

Chi2=646, df=133, p=.000, CFI=.747, RMSEA=.089

MIs show that the model fit could be improved if a path from Ed Env to EC Total would be added.

In this model the standardized effects are:

EC Total ← Behaviour =.066

EC Total ← Education Environment=.035

EC Total ← Ed Attributes=.004

Behaviour ← Education Environment=.084

Education Environment ← Ed Attributes=.030

A8.1.3 | Reflection on the education system

Education attributes as a latent variable shows insignificance in the model, while the manifest variables that load onto the latent variable of Education Attribute have some small effects in the model. Paths between these variables and Behaviour are mostly insignificant as well. Any effects these variables may have in the overall model will be mediated through Education Environment. Notable outcomes of this analysis include that the model fit could be improved if a path from Education Environment to EC Total is added.

A8.2 | Student system

The full student model consisted of the following relations:
Disposition ← Exp diff, Exp Int, Exp performance (combination of Imp P and Exp BSA), Imp Delft
Behaviour ← Focus, DeepLearning, Load, Discipline
Behaviour← Student Attribute variables
EC Total ← Behaviour

A8.2.1 | Cohort 2010

A8.2.1 | Model 1

Student attributes variables included are: Age, SE Maths, SE Physics
Chi2= 561, df=50, p=.000, CFI=.573, RMSEA=.139
Age and SE Physics are not a significant path to Disposition in the model. None of the paths from student attributes to Behaviour are significant.

A8.2.1 | Model 2

Student attributes included are: N Membership, N Impairments, N PR and SE Maths
Chi2= 224, df=50, p=.000, CFI=.810, RMSEA=.072
N Membership, N Impairments, and N PR are not significant paths to Disposition and none of paths from student attributes to Student Behaviour are significant .

A8.2.1 | Model 3

Student attributes included are: Traveltime Total and SE Maths
Chi2= 186 df=50, p=.000, CFI=.834, RMSEA=.072
Traveltime Total to Disposition is not a significant path. None of paths from student attributes to Student Behaviour are significant .

A8.2.1 | Model 4

Student attributes included are: Gender and SE Maths, no paths between student attributes and Behaviour.
Chi2= 241, df=43, p=.000, CFI=.786, RMSEA=.093
Gender is a significant path in the model, but the model fit is worse than for instance model 3.

A8.2.1 | Model 5

Student attributes: skills maths, physics and computer, no paths between student attributes and Behaviour.
Chi2=349, df=53, p=.000, CFI=.706, RMSEA=.103
The path from Skill Computer to Disposition is not significant. The model fit is worse than in model 4.

A8.2.1 | Model 6

Student attribute: SE Maths, no path between SE Maths and Behaviour.
Latent variable Motivation added:
Motivation← Course prior, now, after, Delft prior, now, after, Job prior, now, after.
Disposition ← Motivation
Chi2=.555, df=150, p=.000, CFI=.772, RMSEA=.071
Path from Motivation to Dispositon is not significant in the model.

A8.2.1 | Model 7

Student attribute: SE Maths, no path between SE maths and Behaviour.
Chi2=141, df=34, p=.000, CFI=.863, RMSEA=.077

In this model the standardized effects are:
EC Total ← Behaviour =.591
EC Total ← Disposition=.118
EC Total ← SE Maths= .198
Disposition ← SE Maths=.357
Behaviour ← SE Maths=335
Behaviour ← Disposition=940
A8.2.2 Cohort 2009
Student attributes: Age, SE Physics, SE Maths
Chi2=545, df=61, p=.000, CFI=556, RMSEA=.127
None of the paths is significant, not even the path from Disposition to Behaviour.

A8.3 Combined systems

The combined system was run only for cohort 2010.

A8.3.1 | Combined system with Education Attributes as a latent variable

Education Environment ← TC1, TC2, TS1, TS2, FC1, FC2, OO
Education Environment ← Education Attributes
Education Environment ← SE Maths
Education Attributes ← N Participatory, N Lectures, N Mandatory, N Exams, N Courses

Disposition ← Exp diff, Exp Int, Exp performance (combination of Imp P and Exp BSA), Imp Delft
Disposition ← Education Environment
Disposition ← SE Maths
Disposition ← EC Total
Student Behaviour ← Disposition
Student Behaviour ← Education Environment
Student Behaviour ← Education Attributes
Student Behaviour ← Focus, DeepLearning, Load, Discipline
EC Total ← Student Behaviour

A8.3.1 | Model 1

Full model SEM
Chi2=1190, df=202, p=.000, CFI=.698, RMSEA=.096
The following paths were not significant: Ed Env ← Ed Attr, Ed Env← SE Maths, Behaviour←Ed Env, Behaviour ← Ed Attr, and Disp← EC Total. Education Attributes were dropped as both paths from that latent variable were insignificant in the model. The relation between Education Environment and Behaviour was dropped also.

A8.3.2 | Combined system with Education Attributes as manifest variables

Education Environment ← TC1, TC2, TS1, TS2, FC1, FC2, OO
Education Environment ← Education Attributes
Education Environment ← SE Maths
Education Attributes = N Participatory, N Lectures, N Mandatory, N Exams, N Courses
Disposition ← Exp diff, Exp Int, Exp performance (combination of Imp P and Exp BSA), Imp Delft
Disposition ← Education Environment
Disposition ← EC Total
Disposition ← SE Maths
Student Behaviour ← Disposition
Student Behaviour ← Education Environment
Student Behaviour ← Education Attributes
Student Behaviour ← Focus, DeepLearning, Load, Discipline
EC Total ← Student Behaviour

A8.3.2 | Model 1

Full model SEM
Chi2=1168, df=205, p=.000, CFI=.533, RMSEA=.106

Paths from N Lectures and N Mandatory to Ed Env are not significant in this model. Neither are paths from SE Maths and Ed Env to Behaviour and the path from SE Maths to Ed Env.

A8.3.2 | Model 2

Full model without N Lectures and N Mandatory, without the path from SE Maths to Behaviour, and without the path from Ed Env to Behaviour.
Chi2=1169, df=168, p=.000 CFI=.534, RMSEA=.106

A8.3.2| Model 3

Full model without any of the Education Attribute variables.
Chi2=359, df=117, p=.000,CFI=.823, RMSEA=.062.
This model fit is a lot better than the model including the education attribute variables that we will continue with this reduced model. That being said, it will be worth wile to pursue investigation of the extended model including the education attribute variables in future research with a larger data file, because the number of exams, courses and participatory teaching and learning activities do have small but significant effects on disposition, behaviour and ultimately on EC Total.

A8.4 | Intercepts and variances Bayesian SEM 2010

This table contains the intercepts and variances

Table A8.4.1

	Mean	S.E.	S.D.	C.S.	Median	95% Lower bound	95% Upper bound	Skew	Kurtosis	Min	Max
Intercepts											
Imp Delft	3.870	0.005	0.104	0.001	3.877	3.651	4.053	-0.372	0.102	3.426	4.209
Exp Int	2.819	0.001	0.087	1.000	2.920	2.738	3.080	-0.203	0.110	2.489	3.251
Exp Diff	2.223	0.002	0.095	1.000	2.227	2.026	2.397	-0.264	0.149	1.735	2.537
Exp Perf	5.991	0.007	0.281	1.000	5.998	5.426	6.526	-0.126	0.045	4.400	7.050
TC1	3.690	0.000	0.023	1.000	3.691	3.646	3.735	0.004	0.001	3.602	3.788
TC2	3.792	0.001	0.030	1.000	3.792	3.733	3.852	0.063	0.006	3.675	3.925
TS1	3.003	0.001	0.041	1.000	3.002	2.923	3.082	-0.010	-0.009	2.829	3.162
TS2	3.259	0.000	0.049	1.000	3.259	3.163	3.354	-0.025	0.005	3.050	3.460
OO	3.258	0.000	0.023	1.000	3.258	3.213	3.303	-0.002	-0.029	3.164	3.352
FC1	3.736	0.000	0.028	1.000	3.736	3.681	3.792	0.006	-0.016	3.625	3.861
FC2	3.745	0.000	0.039	1.000	3.745	3.669	3.820	-0.004	0.014	3.578	3.905
Discipline	16.601	0.019	0.781	1.000	16.619	15.016	18.094	-0.126	0.031	13.374	19.606
Load	9.452	0.009	0.451	1.000	9.462	8.544	10.303	-0.124	0.018	7-393	11.273
DpLearn	12.258	0.009	0.367	1.000	12.266	11.508	12.959	-0.150	0.109	10.681	13.813
Focus	12.575	0.008	0.274	1.000	12.584	12.010	13.086	-0.218	0.041	11.363	13.551
EC Total	27.397	0.080	3.025	1.000	27.465	21.270	33.143	-0.151	0.038	13.784	37.892
Variances											
SE Maths	7.240	0.001	0.059	1.000	7.240	7.124	7.356	0.001	-0.064	6.999	7.478

	Mean	S.E.	S.D.	C.S.	Median	95% Lower bound	95% Upper bound	Skew	Kurtosis	Min	Max
Error variances											
Dispostion	0.039	0.001	0.015	1.001	0.038	0.016	0.074	0.631	0.173	0.009	0.106
Imp Delft	0.740	0.001	0.046	1.000	0.739	0.654	0.835	0.207	0.060	0.578	0.950
Exp Int	0.526	0.000	0.034	1.000	0.525	0.465	0.597	0.290	0.179	0.410	0.686
Exp Diff	0.428	0.001	0.028	1.000	0.427	0.376	0.487	0.245	0.093	0.316	0.557
Exp Perf	1.239	0.002	0.114	1.000	1.238	1.020	1.466	0.092	0.110	0.780	1.752
Education Environment	0.149	0.001	0.036	1.000	0.147	0.086	0.224	0.407	0.269	0.047	0.332
TC1	0.143	0.000	0.014	1.000	0.143	0.117	0.172	0.190	0.111	0.088	0.206
TC2	0.320	0.000	0.025	1.000	0.319	0.273	0.371	0.195	0.120	0.224	0.442
TS1	0.768	0.001	0.049	1.000	0.766	0.677	0.869	0.215	0.065	0.583	0.981
TS2	1.154	0.001	0.075	1.000	1.151	1.018	1.312	0.265	0.117	0.875	1.509
OO	0.223	0.000	0.016	1.000	0.222	0.194	0.255	0.232	0.165	0.157	0.300
FC1	0.322	0.000	0.023	1.000	0.321	0.280	0.369	0.209	0.034	0.233	0.428
FC2	0.657	0.001	0.046	1.000	0.655	0.571	0.752	0.231	0.082	0.490	0.859
Behaviour	0.056	0.001	0.054	1.000	0.050	-0.038	0.177	0.615	1.291	-0.215	0.369
Discipline	14.518	0.020	1.143	1.000	14.481	12.383	16.890	0.223	0.162	10.364	20.495
Load	4.262	0.007	0.339	1.000	4.249	3.634	4.959	0.228	0.082	3.048	5.810
DpLearn	3.360	0.003	0.242	1.000	3.351	2.910	3.862	0.218	0.054	2.455	4.416
Focus	4.603	0.006	0.300	1.000	4.592	4.050	5.220	0.230	0.164	3.423	6.197
EC Total	217.870	0.251	16.025	1.000	217.173	188.657	250.884	0.276	0.147	163.424	300.137

A8.5 | Results SEM models 2010

A8.5.1 | Results for SEM model 2010 Figure 7.5

Sample size = 532

Number of distinct sample moments:	170
Number of distinct parameters to be estimated:	53
Degrees of freedom (170 - 53):	117

Regression Weights: (Group number 1 – Default model)

			Estimate	S.E.	C.R.	P
Disposition	<---	Ed_Env	.246	.064	3.832	***
Disposition	<---	SE_Maths	.059	.014	4.372	***
Behaviour	<---	Disposition	3.017	.727	4.152	***
TC1	<---	Ed_Env	1.107	.125	8.834	***
TS2	<---	Ed_Env	1.095	.198	5.533	***
TS1	<---	Ed_Env	.934	.163	5.717	***
OO	<---	Ed_Env	.748	.103	7.269	***
FC1	<---	Ed_Env	1.000			
FC2	<---	Ed_Env	1.268	.175	7.240	***
Load	<---	Behaviour	2.236	.352	6.346	***
DpLearn	<---	Behaviour	1.695	.274	6.183	***
Focus	<---	Behaviour	1.000			
Discipline	<---	Behaviour	3.917	.622	6.296	***
ExpPerf	<---	Disposition	4.206	.823	5.109	***
ExpDiff	<---	Disposition	1.065	.243	4.388	***
ExpInt	<---	Disposition	.868	.224	3.878	***
ImpDelft	<---	Disposition	1.000			
TC2	<---	Ed_Env	1.281	.153	8.393	***
EC_Tot	<---	Behaviour	13.910	2.242	6.205	***

Standardized Regression Weights

			Estimate
Disposition	<---	Ed_Env	.342
Disposition	<---	SE_Maths	.346
Behaviour	<---	Disposition	.949
TC1	<---	Ed_Env	.690
TS2	<---	Ed_Env	.315
TS1	<---	Ed_Env	.328
OO	<---	Ed_Env	.459
FC1	<---	Ed_Env	.498
FC2	<---	Ed_Env	.457
Load	<---	Behaviour	.628
DpLearn	<---	Behaviour	.567
Focus	<---	Behaviour	.328
Discipline	<---	Behaviour	.607
ExpPerf	<---	Disposition	.663
ExpDiff	<---	Disposition	.356
ExpInt	<---	Disposition	.270
ImpDelft	<---	Disposition	.263
TC2	<---	Ed_Env	.595
EC_Tot	<---	Behaviour	.574

Means

	Estimate	S.E.	C.R.	P	Label
SE_Maths	7.241	.059	123.108	***	

Intercepts

	Estimate	S.E.	C.R.	P
ImpDelft	3.846	.106	36.393	***
ExpInt	2.912	.090	32.377	***
ExpDiff	2.218	.092	24.162	***
ExpPerf	5.969	.279	21.408	***
TC2	3.792	.030	125.171	***
TC1	3.690	.023	163.452	***
TS2	3.259	.049	66.650	***
TS1	3.002	.040	75.024	***
OO	3.258	.023	142.190	***
FC1	3.736	.028	132.382	***
FC2	3.745	.039	95.871	***
Discipline	16.518	.795	20.765	***
Load	9.402	.449	20.944	***
DpLearn	12.224	.353	34.645	***
Focus	12.513	.274	45.634	***
EC_Tot	27.121	2.881	9.412	***

Variances

	Estimate	S.E.	C.R.	P
E17	.105	.020	5.173	***
SE_Maths	1.837	.113	16.294	***
E18	.041	.016	2.650	.008
E19	.054	.048	1.118	.264
E14	.315	.025	12.798	***
E13	.142	.013	10.562	***
E12	1.144	.073	15.612	***
E11	.758	.049	15.545	***
E10	.220	.015	14.620	***
E15	.318	.022	14.216	***
E16	.641	.044	14.647	***
E6	1.221	.113	10.836	***
E7	.424	.027	15.485	***
E8	.520	.033	15.864	***
E9	.732	.046	15.889	***
E5	215.081	15.510	13.867	***
E1	14.370	1.072	13.400	***
E3	3.320	.238	13.961	***
E2	4.208	.322	13.065	***
E4	4.538	.289	15.711	***

Standardized Residual Covariances

	SE_Maths	EC_Tot	ImpDelft	ExpInt	ExpDiff	ExpPerf	Discipline	Focus	DpLearn	Load	FC2	FC1	OO	TS1	TS2	TC1	TC2
SE_Maths	.000																
EC_Tot	2.565	.030															
ImpDelft	-1.094	.028	.007														
ExpInt	-4.037	.345	2.340	.007													
ExpDiff	.524	-.786	-2.177	1.197	.013												
ExpPerf	.584	1.567	.522	-.498	.287	.045											
Discipline	-.982	.090	-.376	-.686	-2.329	-.866	.034										
Focus	-2.399	-.840	1.503	1.278	-1.835	-.701	2.346	.010									
DpLearn	.741	-1.110	.695	-.386	1.390	1.679	-.157	-.002	.029								
Load	.437	-.142	-1.036	-.054	1.075	-.978	2.132	-.226	-1.601	.036							
FC2	-.837	-3.247	-.732	1.535	-.566	-2.597	-2.378	-.137	.437	-.926	.000						
FC1	.978	-1.212	.713	3.335	-.022	-.853	-1.077	1.737	.552	2.054	1.523	.000					
OO	1.117	1.114	.281	2.662	2.560	.555	.216	1.063	2.504	1.770	.239	.943	.000				
TS1	-2.972	.353	1.556	5.902	1.425	.587	.416	4.242	2.090	-.136	.066	.056	-.121	.000			
TS2	3.583	.007	-.019	-.169	2.459	.261	-.711	-1.183	2.049	1.356	-.099	-.621	1.897	-1.258	.000		
TC1	.003	-2.298	2.073	3.203	1.800	-1.819	-1.470	.917	1.123	1.290	-1.083	-.425	-.293	.245	.059	.000	
TC2	1.263	-2.954	.029	2.214	2.844	-1.121	-1.319	-.108	1.019	1.064	1.112	-.713	-1.711	-.971	-.196	1.082	.000

Standardized Total Effects

	SE_Maths	Ed_Env	Disposition	Behaviour
Disposition	.346	.342	.000	.000
Behaviour	.329	.325	.949	.000
EC_Tot	.189	.187	.545	.574
ImpDelft	.091	.090	.263	.000
ExpInt	.093	.092	.270	.000
ExpDiff	.123	.122	.356	.000
ExpPerf	.230	.227	.663	.000
Discipline	.200	.197	.577	.607
Focus	.108	.107	.311	.328
DpLearn	.186	.184	.538	.567
Load	.206	.204	.596	.628
FC2	.000	.457	.000	.000
FC1	.000	.498	.000	.000
OO	.000	.459	.000	.000
TS1	.000	.328	.000	.000
TS2	.000	.315	.000	.000
TC1	.000	.690	.000	.000
TC2	.000	.595	.000	.000

Standardized Direct Effects

	SE_Maths	Ed_Env	Disposition	Behaviour
Disposition	.346	.342	.000	.000
Behaviour	.000	.000	.949	.000
EC_Tot	.000	.000	.000	.574
ImpDelft	.000	.000	.263	.000
ExpInt	.000	.000	.270	.000
ExpDiff	.000	.000	.356	.000
ExpPerf	.000	.000	.663	.000
Discipline	.000	.000	.000	.607
Focus	.000	.000	.000	.328
DpLearn	.000	.000	.000	.567
Load	.000	.000	.000	.628
FC2	.000	.457	.000	.000
FC1	.000	.498	.000	.000
OO	.000	.459	.000	.000
TS1	.000	.328	.000	.000
TS2	.000	.315	.000	.000
TC1	.000	.690	.000	.000

Standardized Indirect Effects

	SE_Maths	Ed_Env	Disposition	Behaviour
Disposition	.000	.000	.000	.000
Behaviour	.329	.325	.000	.000
EC_Tot	.189	.187	.545	.000
ImpDelft	.091	.090	.000	.000
ExpInt	.093	.092	.000	.000
ExpDiff	.123	.122	.000	.000
ExpPerf	.230	.227	.000	.000
Discipline	.200	.197	.577	.000
Focus	.108	.107	.311	.000
DpLearn	.186	.184	.538	.000
Load	.206	.204	.596	.000
FC2	.000	.000	.000	.000
FC1	.000	.000	.000	.000
OO	.000	.000	.000	.000
TS1	.000	.000	.000	.000
TS2	.000	.000	.000	.000
TC1	.000	.000	.000	.000
TC2	.000	.000	.000	.000

Modification Indices

Covariances

			M.I.	Par Change
E5	<-->	SE_Maths	10.097	2.909
E5	<-->	E17	11.718	-.879
E8	<-->	SE_Maths	18.589	-.185
E8	<-->	E17	20.059	.054
E8	<-->	E9	6.561	.070
E7	<-->	E17	6.195	.027
E7	<-->	E9	6.284	-.062
E6	<-->	E17	6.654	-.052
E6	<-->	E5	8.118	2.347
E1	<-->	E17	5.654	-.160
E1	<-->	E19	13.692	.434
E1	<-->	E7	10.692	-.382
E4	<-->	SE_Maths	7.228	-.342
E4	<-->	E7	4.325	-.129
E4	<-->	E1	11.752	1.306
E3	<-->	E17	5.455	.074
E3	<-->	E19	12.757	-.201
E3	<-->	E5	4.003	-2.587
E3	<-->	E6	8.078	.290
E2	<-->	E17	4.069	.074
E2	<-->	E6	5.076	-.264
E2	<-->	E1	17.196	1.607
E16	<-->	E18	7.230	-.024

			M.I.	Par Change
E15	<-->	E2	4.184	.117
E15	<-->	E16	4.825	.047
E10	<-->	E18	5.302	.012
E11	<-->	SE_Maths	11.653	-.178
E11	<-->	E18	11.832	.033
E11	<-->	E8	24.408	.138
E11	<-->	E4	16.038	.332
E11	<-->	E2	4.023	-.171
E12	<-->	SE_Maths	13.176	.232
E12	<-->	E4	4.560	-.217
E12	<-->	E10	5.736	.055
E13	<-->	E9	5.868	.039
E13	<-->	E16	4.344	-.032
E14	<-->	E5	6.890	-1.079
E14	<-->	E7	6.469	.045
E14	<-->	E10	7.725	-.036
E14	<-->	E13	5.969	.027

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	53	359.666	117	.000	3.074
Saturated model	170	.000	0		
Independence model	34	1503.994	136	.000	11.059

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.761	.722	.825	.794	.823
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.062	.055	.070	.003
Independence model	.138	.131	.144	.000

A8.5.2 | Results for SEM model 2010 Figure 7.6

Sample size = 532

Number of distinct sample moments:	170
Number of distinct parameters to be estimated:	54
Degrees of freedom (170 - 54):	116

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Disposition	<---	Ed_Env	.381
Disposition	<---	SE_Maths	.335
Behaviour	<---	Disposition	.948
TC1	<---	Ed_Env	.688
TS1	<---	Ed_Env	.329
OO	<---	Ed_Env	.461
FC1	<---	Ed_Env	.500
FC2	<---	Ed_Env	.456
Load	<---	Behaviour	.635
DpLearn	<---	Behaviour	.566
Focus	<---	Behaviour	.335
ExpInt	<---	Disposition	.279
ImpDelft	<---	Disposition	.264
TC2	<---	Ed_Env	.593
EC_Tot	<---	Behaviour	.561
TS2	<---	Ed_Env	.318
Discipline	<---	Behaviour	.674
Discipline	<---	Ed_Env	-.142
ExpDiff	<---	Disposition	.358
ExpPerf	<---	Disposition	.649

Means: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
SE_Maths	7.241	.059	123.108	***	

Intercepts

	Estimate	S.E.	C.R.	P
ImpDelft	3.858	.104	37.201	***
ExpInt	2.912	.089	32.714	***
ExpDiff	2.231	.091	24.648	***
ExpPerf	6.064	.272	22.292	***
TC2	3.792	.030	125.171	***
TC1	3.690	.023	163.452	***
TS2	3.259	.049	66.650	***
TS1	3.002	.040	75.024	***
OO	3.258	.023	142.190	***
FC1	3.736	.028	132.382	***
FC2	3.745	.039	95.871	***
Discipline	16.147	.860	18.774	***
Load	9.467	.445	21.291	***
DpLearn	12.301	.346	35.540	***
Focus	12.531	.270	46.430	***
EC_Tot	28.127	2.787	10.091	***

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P
E17	.168	.036	4.695	***
SE_Maths	1.837	.113	16.294	***
E18	.041	.015	2.658	.008
E19	.058	.049	1.167	.243
E14	.316	.025	12.865	***
E13	.142	.013	10.657	***
E12	1.142	.073	15.605	***
E11	.758	.049	15.546	***
E10	.219	.015	14.617	***
E15	.317	.022	14.217	***
E16	.642	.044	14.671	***
E6	1.262	.112	11.244	***
E7	.423	.027	15.476	***
E8	.517	.033	15.834	***
E9	.731	.046	15.887	***
E5	219.877	15.593	14.101	***
E1	13.563	1.089	12.451	***
E3	3.323	.237	14.041	***
E2	4.143	.318	13.038	***
E4	4.516	.288	15.703	***

Standardized Residual Covariances: (Group number 1 - Default model)

	SE_Maths	Discipline	EC_Tot	ImpDelft	ExpInt	ExpDiff	ExpPerf	Focus	DpLearn	Load	FC2	FC1	00	TS1	TS2	TC1	TC2
SE_Maths	.000																
Discipline	-1.307	.023															
EC_Tot	2.809	.085	.036														
ImpDelft	-1.036	-.436	.097	.009													
ExpInt	-4.037	-.849	.323	2.281	.010												
ExpDiff	.601	-2.412	-.697	-2.195	1.115	.016											
ExpPerf	.859	-.799	1.940	.594	-.537	.380	.054										
Focus	-2.365	2.141	-.821	1.462	1.180	-1.893	-.682	.013									
DpLearn	.888	-.329	-.933	.693	-.482	1.384	1.878	-.076	.037								
Load	.542	1.827	-.043	-1.084	-.208	1.007	-.875	-.369	-1.672	.046							
FC2	-.837	-1.372	-3.409	-.841	1.392	-.714	-2.802	-.283	.229	-1.185	.000						
FC1	.978	.018	-1.402	.588	3.172	-.193	-1.092	1.568	.312	1.754	1.519	.000					
00	1.117	1.228	.935	.165	2.511	2.401	.330	.906	2.280	1.491	.231	.904	.000				
TS1	-2.972	1.141	.227	1.473	5.795	1.312	.428	4.131	1.932	-.333	.063	.032	-.146	.000			
TS2	3.583	-.021	-.121	-.102	-.275	2.345	.099	-1.293	1.889	1.158	-.119	-.662	1.855	-1.285	.000		
TC1	.003	.047	-2.542	1.907	2.985	1.574	-2.126	.694	.808	.896	-1.055	-.436	-.309	.238	.027	.000	
TC2	1.263	-.006	-3.161	-.112	2.029	2.650	-1.384	-.298	.749	.726	1.143	-.715	-1.718	-.972	-.219	1.124	.000

Standardized Total Effects: (Group number 1 - Default model)

	SE_Maths	Ed_Env	Disposition	Behaviour
Disposition	.335	.381	.000	.000
Behaviour	.318	.362	.948	.000
Discipline	.214	.101	.639	.674
EC_Tot	.178	.203	.532	.561
ImpDelft	.088	.101	.264	.000
ExpInt	.093	.106	.279	.000
ExpDiff	.120	.136	.358	.000
ExpPerf	.218	.247	.649	.000
Focus	.106	.121	.317	.335
DpLearn	.180	.205	.537	.566
Load	.202	.230	.602	.635
FC2	.000	.456	.000	.000
FC1	.000	.500	.000	.000
OO	.000	.461	.000	.000
TS1	.000	.329	.000	.000
TS2	.000	.318	.000	.000
TC1	.000	.688	.000	.000
TC2	.000	.593	.000	.000

Standardized Direct Effects: (Group number 1 - Default model)

	SE_Maths	Ed_Env	Disposition	Behaviour
Disposition	.335	.381	.000	.000
Behaviour	.000	.000	.948	.000
Discipline	.000	-.142	.000	.674
EC_Tot	.000	.000	.000	.561
ImpDelft	.000	.000	.264	.000
ExpInt	.000	.000	.279	.000
ExpDiff	.000	.000	.358	.000
ExpPerf	.000	.000	.649	.000
Focus	.000	.000	.000	.335
DpLearn	.000	.000	.000	.566
Load	.000	.000	.000	.635
FC2	.000	.456	.000	.000
FC1	.000	.500	.000	.000
OO	.000	.461	.000	.000
TS1	.000	.329	.000	.000
TS2	.000	.318	.000	.000
TC1	.000	.688	.000	.000
TC2	.000	.593	.000	.000

Standardized Indirect Effects: (Group number 1 - Default model)

	SE_Maths	Ed_Env	Disposition	Behaviour
Disposition	.000	.000	.000	.000
Behaviour	.318	.362	.000	.000
Discipline	.214	.244	.639	.000
EC_Tot	.178	.203	.532	.000
ImpDelft	.088	.101	.000	.000
ExpInt	.093	.106	.000	.000
ExpDiff	.120	.136	.000	.000
ExpPerf	.218	.247	.000	.000
Focus	.106	.121	.317	.000
DpLearn	.180	.205	.537	.000
Load	.202	.230	.602	.000
FC2	.000	.000	.000	.000
FC1	.000	.000	.000	.000
OO	.000	.000	.000	.000
TS1	.000	.000	.000	.000
TS2	.000	.000	.000	.000
TC1	.000	.000	.000	.000
TC2	.000	.000	.000	.000

Modification Indices: (Group number 1 - Default model)

Covariances: (Group number 1 - Default model)

			M.I.	Par Change
E1	<-->	SE_Maths	4.236	-.489
E1	<-->	E19	9.916	.362
E5	<-->	SE_Maths	11.647	3.141
E5	<-->	E17	13.870	-1.215
E8	<-->	SE_Maths	18.876	-.186
E8	<-->	E17	17.772	.064
E8	<-->	E9	6.263	.068
E7	<-->	E17	5.421	.032
E7	<-->	E1	10.012	-.367
E7	<-->	E9	6.424	-.063
E6	<-->	E17	8.585	-.076
E6	<-->	E1	4.201	-.440
E6	<-->	E5	11.516	2.835
E4	<-->	SE_Maths	7.146	-.339
E4	<-->	E1	11.906	1.299
E4	<-->	E7	4.610	-.133
E3	<-->	E19	12.686	-.202
E3	<-->	E6	9.663	.320
E2	<-->	E1	15.525	1.499
E2	<-->	E6	4.086	-.237
E2	<-->	E3	10.695	-.598
E16	<-->	E18	7.110	-.024
E15	<-->	E2	4.070	.114

			M.I.	Par Change
E15	<-->	E16	4.796	.047
E10	<-->	E18	5.150	.012
E11	<-->	SE_Maths	11.914	-.180
E11	<-->	E18	11.685	.033
E11	<-->	E8	24.100	.137
E11	<-->	E4	16.209	.333
E11	<-->	E2	4.215	-.174
E12	<-->	SE_Maths	12.943	.230
E12	<-->	E4	4.496	-.215
E12	<-->	E10	5.514	.054
E13	<-->	E9	5.353	.038
E13	<-->	E6	4.308	-.048
E13	<-->	E16	4.079	-.031
E14	<-->	E5	7.654	-1.144
E14	<-->	E7	5.553	.041
E14	<-->	E10	7.772	-.036
E14	<-->	E13	6.363	.028

Model Fit Summary: (Group number 1 - Default model)

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	54	351.948	116	.000	3.034
Saturated model	170	.000	0		
Independence model	34	1503.994	136	.000	11.059

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.766	.726	.830	.798	.828
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.062	.055	.069	.004
Independence model	.138	.131	.144	.000

List of publications

Publications related to this dissertation

Journal papers

Forsman, J., Van den Bogaard, M. E. D., Linder, C., & Fraser, D. M. (2014).
Considering Student Retention as a Complex System: A Possible Way Forward for enhancing Student Retention. *European Journal of Engineering Education*, published online. doi:10.1080/03043797.2014.941340

Forsman, J., Mann, R.P., Linder, C., Van den Bogaard, M.E.D. (2014).
Sandbox University: Estimating Influence of Institutional Action. *Plos One* 9(7):9. doi:10.1371/journal.pone.0103261

Van den Bogaard, M.E.D. (2012).
Explaining student success in engineering education at Delft University of Technology: a literature synthesis. *European Journal of Engineering Education* 37(1):59-82. doi:10.1080/03043797.2012.658507

Conference proceedings

Van den Bogaard, M.E.D., Sjoer, E. (2014).
Preliminary evaluation of an intervention to increase student success of first year students in engineering education. In: *Proceedings of the 42st SEFI Annual Conference* Birmingham. SEFI & University of Birmingham, Birmingham, UK.

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Curriculum Vitae

Maartje van den Bogaard was born in Hooge and Lage Zwaluwe on November 19, 1978. She finished her pre-university education at the Alberdink Thijm College in Hilversum in 1996 and pursued a master degree in pedagogy and education sciences at the University of Groningen. She graduated in 2003, after having participated in a management course at the faculty of business and economics and a year abroad: studying education administration at Minnesota State University Moorhead, USA. Maartje briefly worked at IVA Tilburg, an institute for policy research, before she joined Delft University of Technology in 2005 and worked as a course manager, education consultant, teacher and a PhD candidate. She currently works at the ICLON at Leiden University.

Tot slot

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Maartje van den Bogaard

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"Think boldly, tread lightly."
(Peter Yealands)