Communicating the Nanobiology Bachelor to VWO high school students

Suggestion for a content based matchmaking information strategy aimed at 5VWO and 6VWO high school students.

Ammeret Rossouw

Graduation report

MSc Science Education and Communication

September 2012

TU Delft Delft University of Technology

Science Education and Communication

In happy memory of my grandfather, who was born
on a 25 september day
many years ago…

He would’ve been pretty excited to see this day!

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Summary

Context, research question and main result

Students starting off on a tertiary education program but then dropping out again before obtaining their degree is a big problem worldwide. One of the most important reasons mentioned for this is "making the wrong study choice". Proper information can help high school students to make a 'right' choice.

The Delft University of Technology, together with the Erasmus University Rotterdam, just started up a new joint bachelor program "Nanobiology". Their very first students are starting their education this year, 2012-2013. Because the program is brand new it is crucial for prospective students as well as for the program that as little as possible students make 'the wrong study choice' by enrolling in the program. To address this challenge the Head of Marketing, Information and Communication invited me to do a graduation research on the topic of study choice and study success, using the Nanobiology bachelor's program as a case. The research question that will be answered is:

In order to contribute towards preventing dropout in the future Nanobiology student population, by a) <u>encouraging</u> prospective students with a <u>high probability to be successful in the program</u>, to consider enrolment, while b) <u>discouraging</u> prospective students who have a <u>low probability to be successful in the program</u>, from enrolment: which information elements about the Nanobiology program should be emphasized in communication with high school students?

The answer this research gives to the question is: content related to the "Exact" side of the program should be emphasized in communication with high school students from the target group. The main target group is 5 and 6 VWO students with an NT or NG profiles. In this way students that 'fit' the study - where 'fit' is defined in terms of interest in the study as well as success probability in the study - are attracted, while students that do not 'fit' the study are repelled. Also, emphasis on the generalist careers types "science journalist" and "science advisor" - that can be pursued through a much broader range programs apart from this particular study - should be avoided, as this would have the opposite effect.

This research also uncovered other themes and career types that are core to the Nanobiology bachelor in the minds of the target population. These are:

<u>Program content theme's:</u> "Biomedical/Molecular Biology"; "Exact/STEM related"; "Unfamiliar/Nanobiology specific"; and "Fundamental Science".

<u>Other program theme's:</u> International; Innovative/specialist;

<u>Career type theme's:</u> Technical/Scientific career emphasis; Biomedical career emphasis; Generalist or "Alpha Direction".

Method used

To answer the research question both qualitative and quantitative methods were used. The qualitative methods included: 1) a literature study to uncover the factors that

influence high school students' in choosing a higher education program as well as the factors associated with success in higher education programs; and 2) a qualitative analysis of what constitutes the Nanobiology program, primarily in terms of program content and career perspectives. A questionnaire was developed from this and used to sample the target group, measuring indicators of interest in the Nanobiology program as well as future success probabilities in studying the program. The total sample consisted of 440 5VWO respondents with NT, NG or double profiles. Part of the methodology was to segment the sample population in terms of the measured indicators of interest and success. Using cluster analysis four segments appeared: two interested segments, "dream" and "risky" – the first with high success chances and the second with low success chances - and two uninterested segments, "potential" and "rest". Only the first two segments turned out to be of real interest. The "Exact/STEM related" theme within the Nanobiology program received a positive score from the "dream" cluster and negative scores from the "risky" cluster, making it the perfect theme to emphasize in informing the target group.

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1 Introduction

1.1 Background of the research

Students starting off on a tertiary education program but then dropping out again before obtaining their degree is a big problem worldwide. Because it has such big economic and societal effects, intense research has been carried out into this phenomenon over the past 50 years (Tinto, 1975[1]). Dropout has consequences not only at the micro level of the individual student and the macro level of society at large but also at the meso level of tertiary education institutions and their departments.

One of the most important reason for dropout[2] (Van den Broek et al., 2009), is 'having made the wrong study choice.' The topic of how students make study choices is therefore closely related to the topic of dropout.

With 33% of students in the Netherlands dropping out of higher education during their first year (Leest, 2011) the problem of dropout and the question how high school students make a choice for a tertiary education institute and program is also very important in this country. Especially in relation to Beta-Technical studies, because of the growing demand for workforce educated in this area, and the decline of interest in this direction amongst high school students. In addition to this, new government policy with regard to higher education, heavily fining students who do not finish their programs in time together with their universities[3], will be enforced in practice this year for the first time. The financial cost of dropout for both students and universities will therefore become intensified. Making 'the right choice' therefore becomes even more important. The question arises, what can be done to encourage these 'right chioces' to be made?

The issues mentioned above on the costs of dropout and the importance of students making a proper study choice become intensified when it concerns a brand new program. The stakes are higher, especially for the institution offering the program, and the risks are bigger, especially for the student. The student choosing to enroll in a brand new program instead of an established program cannot talk to students already in the program to hear their experiences; has no examples available of possible career paths after the study; and has relatively little to base his/her trust in future educational quality of the program upon. The brand new program itself on the other hand depends much more intensely on the students recruited for development of it's quality, identity and ultimately it's survival than an established program.

For new programs it is therefore even more important than for established programs to recruit the 'right' type of student: a student that will fit the program and help shape it; fit and help shape his/her peers; and ultimately be successful in the program. Figuring out what type of student will fit a program that is brand new is off course very hard. This makes it a challenge for new programs to recruit the 'right' student, and for high school students to determine whether they fit with the program. New programs therefore serve as very interesting case-studies as well as very thankful commissioners for research into high school student study choice and future success.

The Delft University of Technology, together with the Erasmus University Rotterdam, are about to start a new bachelor program "Nanobiology", combining (quantitative) Molecular Biology with (Applied) Physics:

[1] Tinto (1975) reviews some of the early work in this area.
[2] mentioned just below 'personal problems' in Van den Broek et al., 2009
[3] The so called 'langstudeerboete'. The measure is under discussion however.

an interdisciplinary program which is brand new in both character and content. Traditionally, (Molecular) Biology and Physics are not taught together and form rather separate disciplines. The aim of combining these two scientific fields in a truly interdisciplinary program is new and anticipates an ongoing development in scientific practice of the two fields growing towards each other. The program has no direct comparison in the Netherlands. Because the program is brand new it is of utmost importance to the current and future success and quality of this new program to recruit the 'right' students in its startup years, especially as the study is intended to be small scale (~50 students per year). The students recruited in the first years will co-shape the program and co-shape their peers' academic experience to a very large extent. A high-dropout rate could pose big problems. A student body that does not fit with the program could pose big challenges too. The question therefore arises, *what measures can be taken to encourage matchmaking between student and program? In other words, what measures can be taken to raise the probability that the students who fit the Nanobiology program and have a high probability of being successful in it are indeed the ones that enroll in the program?*

All of the above forms the background of this research. To address the question described above, the head of Marketing and Communication at the Department of TNW of the Delft University of Technology invited me to do my graduation research with them, using the Nanobiology program as a case-study.

Since the role of a university department's marketing, information and communications team in this process is limited - the best the university can do is to provide proper information to the student – some of the questions the university department's marketing, information and communications team faces are: *what constitutes proper information about a program? Can proper information even really contribute to help students make the 'right' study choice and in this way help lower the dropout rate? And if yes, which type of information should be emphasized in order to achieve this goal? Of all the information there is about a program, what should be included in the limited space of a flyer or a website and in the limited time of a presentation on the program's open days?* These questions bring us to the research goal and question of this thesis, that will follow in the next section.

Relation to my master program: Science Education and Communication

This thesis is a graduation project of the master program Science Education and Communication at the Delft University of Technology in The Netherlands. How can this research topic be related to the discipline I am graduating in: Science Education and Communication?

First, this research is clearly positioned at the borderline between science (the content of the Nanobiology program), education (the goal of the Nanobiology program) and communication (one of the tools that can be used to overcome the challenges for establishment of the Nanobiology program). Because I have a background in the content of the program (as a Bionanoscience graduate) and am now combining this with a science education and communication masters' program, I am in a good position for doing this type of border area research.

Secondly, there are two big challenges that the marketing, information and communication department faces in informing high school students eligible for enrolment in their program. One is the challenge of choosing the right information elements or concepts to use in their information efforts, the other one is to use the correct type of terminology. It is a challenge to translate the concepts from higher education into concepts that are familiar to high school students and at the same time similar to the higher education concepts, as these worlds are far apart. Concept context learning in Science & Technology education therefore forms an important part of the research at the Department of Science Education and Communication. One goal is to understand how high school pupils learn (science and technology) concepts. Another goal is to get hold of the core concepts that define science and technology (see for example

Rossouw et al., 2010). I believe that with this theses I can provide the marketing, information and communication department with the information they need in order to reach this goal.

1.2 Scope and Aim

The problem I want to address with this research is high school student dropout due to students making the wrong study choice. As my commissioner is the marketing department of the faculty TNW at the TU Delft, I will look for solutions that can be executed by their marketing, information and communications department. As their main activity is informing prospective students, the question is if proper information can help students self-select, 'match' themselves to a study that fits them so that they won't drop out again because they discover that it's been a wrong study choice. The question then becomes, what type of information can help students self select in a way that lowers dropout rates?

According to Leest (2011), students make a choice regarding tertiary education at two levels: the institutional level and the program level. Half of the general Dutch student population first choose their program and then there university. The other half first choose the university and then the program or choose both at the same time[4] (Leest, 2011). Because my commissioner's interest lies in the program level, I will only look at choice processes concerning higher education programs and not choice processes concerning universities.

Ethical considerations

As mentioned before, study choices have big consequences at many levels, not only at the level of the higher education institution offering the study program. An individual's study choices will greatly influence his or her life and all the individual's combined choices will shape a nation to a large extent. Considering that on top of this, universities in the Netherlands are largely publicly funded, this raises questions regarding the ethical aspects of influencing student's study choices with university marketing. Considering the diversity of stakeholders and the diversity of their needs, this is a very complex subject. I will not dive into this ethical issue in this research, but will touch upon it briefly in the discussion.

1.3 Research goal and question

The question that will be addressed in this thesis is: *"In order to contribute towards preventing dropout in the future Nanobiology student population, by a) <u>encouraging</u> prospective students with a <u>high probability to be successful</u> in the program, to consider enrolment, while b) <u>discouraging</u> prospective students who have a <u>low probability to be successful</u> in the program, from enrolment: which information elements about the Nanobiology program should be emphasized in communication with high school students?*

The research goal becomes:

"To determine which (content) aspects of the Nanobiology bachelor's program should be emphasized in the communication with (5th and) 6th year VWO high school students about this program, in order to inform and attract students that are likely to succeed in the Nanobiology bachelor's program and inform and discourage students that are unlikely to succeed in the program."

Research (Bloemen & Dellaert, 2000), (Van den Broek et al., 2009) has shown that content is the most important single factor influencing students' study choice. It also shows the strongest correlation with not

[4] Interestingly these percentages are slightly different for TU Delft. Of the TU Delft population about one third of students first chose their institution and then the program, one third first chose their program and then their institution and one third chose these two more or less simulteneously (LEEST, 2011).

changing the chosen study and expecting to finish the study, which is how Broek (Broek et al., 2009) defines "making the right study choice". In this study the emphasis will therefore be on content elements of the program.

If there are content aspects of the Nanobiology program that have an attracting influence on students that are likely to succeed in this program, and at the same time a repelling influence on students that are unlikely to succeed in the Nanobiology program, these content aspects could be used to develop strategic communication.

To uncover these elements, the population first has to be segmented in terms of attraction towards the Nanobiology program and likelihood of study success in this program. This will give us roughly four segments or four types of students within the target population:

a) students that are attracted to the program and likely to succeed in the program (the 'dream' student)

b) students that are attracted to the program but unlikely to succeed in the program (the 'risky' student)

c) students that are not attracted to the program but nevertheless likely to succeed in the program (the 'potential' student)

d) students that are neither attracted to the program nor likely to succeed in the program (the 'rest' student)

The attractiveness of each (content) aspect of the program can then be measured for the various segments.

Communication efforts towards the 'dream' and the 'rest' students are the easiest. Any type of honest communication towards students in these segments would encourage them to follow their natural inclinations and this seems best for both the program and the student. However, the 'risky' student might be encouraged to enroll if communication towards this student is not well thought through. This could prove to be a problem for both the student and the program, as this type of student might discover that the program is too difficult or doesn't fit him/her. Knowing which program (content) aspects repel this type of student could be very valuable for both the student and the program as emphasis on these aspects could encourage this type of student to reconsider enrolment in this program.

Research sub questions:

Summarizing, this results in the following research sub questions:

I) What factors besides 'content', influence higher education study choice of high school students that are eligible to enroll in a Beta-Technical higher education? And what is the relative importance attached to each of these factors by the target group?

II) What are the core (content) aspects that define the Nanobiology program?

III) Using the answer to I), which (content) aspects of the Nanobiology program could influence the study choice of the target group?

IV) What factors influence student success likelihood in higher education programs, in particular in programs that resemble the Nanobiology program?

V) Could emphasis on some of these (content) aspects of the Nanobiology program serve as controls in marketing, to attract students from so called "dream segments" and repel students from so called "risky" segments using the exact same marketing material?

VI) Are there differences in the relative importance attached to the choice factors found in I) for different segments of the target population? If so, could these be used as additional controls in segmented marketing?

The strategy that will be followed to answer the sub questions, is the following:

Sub question I) and IV) will be answered by means of a literature review. The outcome of the literature review for I) will also be checked empirically in a questionnaire taken with the target group. Sub question II) will be answered by means of a qualitative analysis of the Nanobiology bachelor's program, to uncover the core aspects that define this program in terms of the factors found in I). Sub question III) will be answered empirically, by means of a questionnaire and subsequent quantitative analysis. Sub question V) and VI) will be answered by means of quantitative analysis of the results from the survey. This will be done by a) segmenting the respondent population; b) calculating the mean score per segment for each (content) aspects of the program; c) comparing the mean scores between the segments and d) comparing the relative importance attached to the choice factors between the segments.

The outcome of all of this could inform strategic marketing and communication, aimed at encouraging "prospective students with a high probability to be successful in the study", to consider enrolment – while discouraging "prospective students with a low probability to be successful in the study" from enrolment. This could then possibly contribute towards preventing dropout in the future Nanobiology student population. This would then hopefully benefit both the Nanobiology program, which is vulnerable as it is just starting up, and prospective students, who are vulnerable too considering the economic situation of today and the strict new rules about to be applied by government, to impose fines on students that do not finish their studies in time. As we saw, making the wrong study choice could be a costly matter to both student and program and contributions towards preventing this could therefore benefit both parties.

1.4 Outline of this report

The rest of the report contains the following:

In Chapter 2, "Method", the research method will be described in a qualitative and a quantitative part. The outcome of the qualitative part is used to design a questionnaire and the questionnaire results are used as input for the quantitative part. The qualitative part describes the literature search and the analysis of the Nanobiology bachelor's program. The quantitative part describes the built up of the questionnaire and the analysis of the outcome of questionnaires, for which the statistical analysis program SPSS is used.

In Chapter 3, "Theory", the first section gives an overview of study choice factors as well as the literature used to find and validate these factors. Similarly, the second section gives an overview of study success factors found in the literature as well as an overview of the literature used to find and validate these factors. In both cases the emphasis will be on the factors relevant for Beta-Technical higher education. The second section also includes a discussion of the relation between study choice and study success factors.

Chapter 4, "Instrument Development and Analysis", presents the results of the qualitative analysis of the Nanobiology program (section 4.1), the development of the questionnaire (section 4.2) and the outcome of the quantitative analysis of the questionnaires done in SPSS (section 4.3-4.6). The chapter concludes with section 4.6, discussing the validity and reliability of the results. A discussion of the validity and reliability of the results follows in section 4.7. Section 4.8 concludes the chapter summarizing the main results necessary for answering the research questions.

In Chapter 5 "Conclusions" the main conclusions will be presented by means of answers to the research questions.

Chapter 6 "Discussion" takes a step back and discusses the results and conclusions from this research in relation to the existing literature. It also discusses the relationship of this research to the field of Science Communication and gives a reflection on higher education marketing.

In Chapter 7 "Recommendations" I will give recommendations to my commissioner based on the results, conclusions and discussion chapters.

2 Method

To answer the research question and reach the research goal established in the previous chapter, both qualitative and quantitative methods were used. These methods will be described in this chapter in two parts: a qualitative part and a quantitative part. Section 2.1 gives an overview of the entire methodology. Sections 2.2 and 2.3 describe the qualitative part of the methodology which consists of a) a literature study (section 2.2) and b) a qualitative analysis of documents and video material that describe the Nanobiology program (section 2.3). Based on the outcome of the qualitative part of the research, a questionnaire was developed (section 2.4). The outcome of the questionnaire was analyzed quantitatively using methods described the same section.

2.1 Overview of the methodology

As established in the previous chapter, my research goal is: "*To determine which (content) elements of the Nanobiology bachelor's program should be emphasized in the communication with (5th and) 6th year VWO high school students about this program, in order to inform and attract students that are likely to succeed in the NB bachelor's program and inform and discourage students that are unlikely to succeed in the program."* To reach this goal I will use a combination of qualitative and quantitative methods that will be described in this chapter. The first half of the research will be mainly qualitative and aims at a) uncovering the main factors that influence study choice and study success and b) uncovering the core (content) aspects of the Nanobiology program. By matching the core aspects found in b) with the factors influencing study choice found in a), a list can be made of the aspects of the Nanobiology program that will have a strong influence on the choice process of high school students. Based on the outcome of the qualitative part of the research, a questionnaire will be developed. The outcome of the questionnaire will be analyzed quantitatively with the purpose of a) uncovering themes in the core content aspects of the program (using factor analysis); b) segmenting the target group in terms of their likeliness to choose the program and their likeliness to be successful in the program (using cluster analysis) and c) to determine for each segment how attracted the high school students are to the various aspect themes of the Nanobiology program (using difference tests such as the Mann-Whitney U test). The ideal results I hope to find in this way are program aspect theme's that are: a) attractive to students that have a high chance of choosing this study as well as a high study success likelihood, and that are at the same time b) repelling to students that have a high chance of choosing this study but a low study success likelihood. Finally, background characteristics such as gender, VWO study profile and Beta-Technical orientation of the different segments will be analyzed. The purpose of this last step is to determine if the various segments are distinct from each other in terms of these characteristics. This characterization of the segments could serve as extra validation of the results and could help to better know and understand the various segments of the target population.

Figure 2.1 below gives an illustration of how the final outcome can be used in strategic information by the marketing, information and communications department.

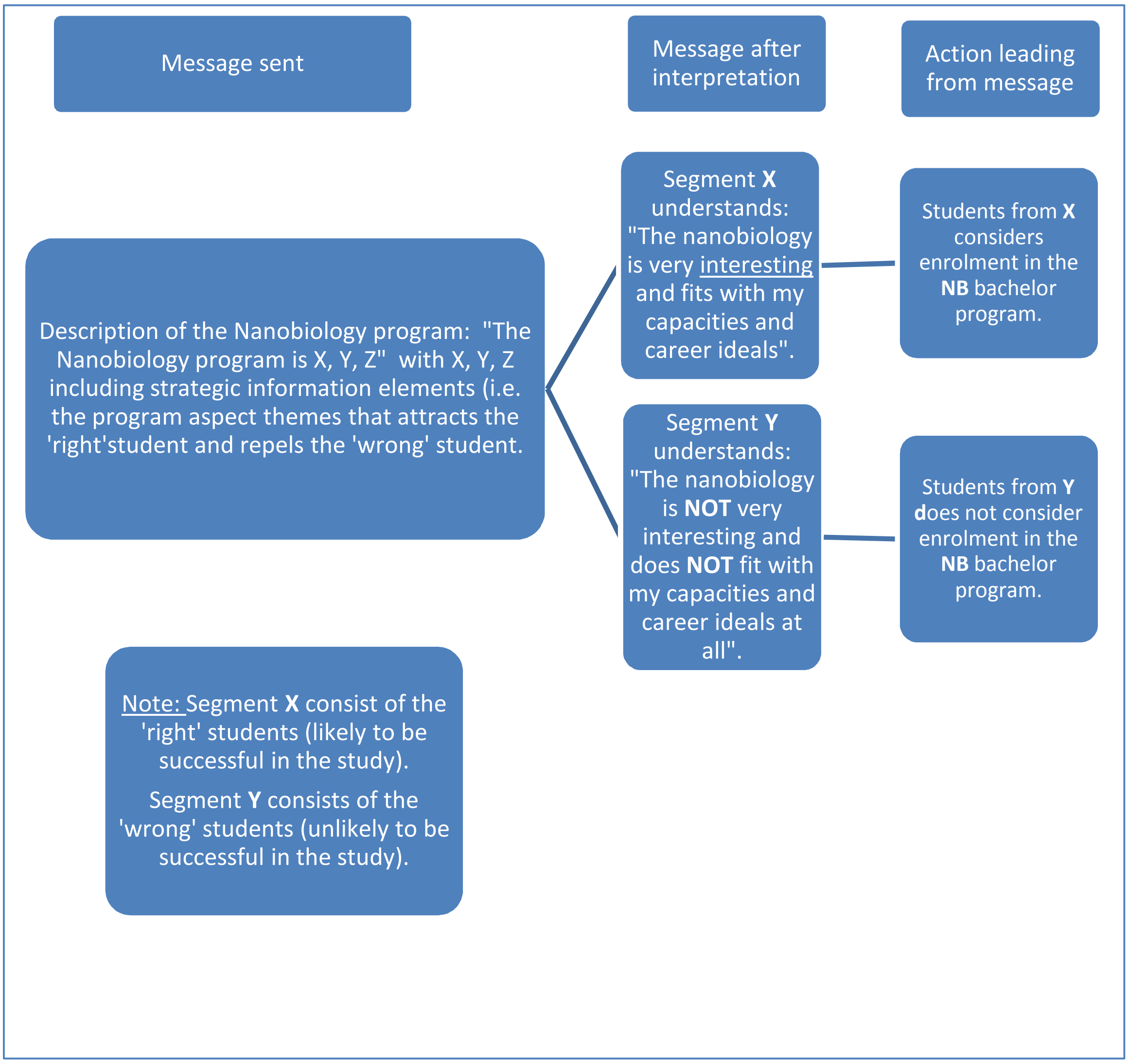


Figure 2.1: Visualization of how the final outcome can be used in marketing and communication to reach their communication goal.

2.2 Qualitative Research Part 1: Literature Study

Different types of literature have been used to understand study choice and study success:

- Research commissioned by governments and universities (providing vast amounts of very relevant empirical data);
- Science Education literature (researching how interest in science works and how it can be influenced);
- Engineering Education literature (researching persistence and success in engineering education);
- Psychology literature (researching what are the constructs (constraints?) that influence choice and success and the influence of self-efficacy on all of it);
- Vocational literature, i.e. Vocational Psychology (trying to understand vocational pathways);
- Economics of Education (STEM graduates are important for economic competitiveness);
- Higher Education Marketing (to understand the role that marketing can have in stimulating enrolment and success).

- Sociological and communication research to understand the current state of societal attitudes towards Nanotechnology, a separate short literature search was conducted.

Literature search for choice and success factors

To get an understanding of the topic of higher education choice processes of high school students, I started searching the internet database Web of Knowledge, using the following keywords – choice, student, education, high, school, college, choice (AND process(es) OR determinant), university, program, AND (STEM OR physics OR biology), nanotechnology, nanoscience – in various combinations (see Appendix 1).

As this gave very few useful results I switched to another search strategy using full sentences in Google (scholar). References from the (grey) literature found in this way were looked up if they contained the keywords mentioned above for the Web of Knowledge search or concepts related to these keywords. My commissioner and her colleague also gave me documents related to these same keywords. See Table 2.1 for the sentences used in Google (scholar), the documents found to contain valuable references (marked with *) and the documents finally used (marked with a † sign and printed in bold). The documents finally used proved very valuable and lists of study choice factors and success factors could already be made using only this material. To validate the factors found in this highly exploratory way, a more thorough literature search in the database Web of Knowledge was conducted later in the research process. See tables in Appendix 3 for the keywords and search combinations used.

Table 2.1: Exploratory literature search on study choice

Database/Search engine used	**Keywords used**	**Main articles/documents found**
Web of Knowledge (Topic search)	- choice AND student AND education - highschool AND student AND college AND choice AND processes - university AND program AND choice AND (process OR determinant) AND high AND school AND (STEM OR physics OR biology) - "university AND choice AND high AND school? AND ("nanotechnology" OR "nanoscience")	- none - none - none: focus is mostly on medicine and medical students - none
Web of Knowledge Topic search (at a later stage)	- program AND choice AND student AND higher AND education, Refined by: Netherlands	- One interesting article (VanVonderen, 1996) † led to a snowball effect via references, leading to Tinto (1975) † and the name 'Eccles'.
Google Scholar	- "choosing tertiary education in Holland" - "model keuzeproces vervolgopleiding middelbare scholieren", leading to more interesting references. - "model keuzeproces beta vervolgopleiding middelbare scholieren"	- Dekker (1996): only abstract - **Berkhout & Leeuwen, 2000** † - Knoop, 2008* - **Biermans, 2003** †
Google	- "college choice processes of high school students" - "Wat vinden middelbare scholieren belangrijk bij het kiezen van een vervolgopleiding? Welke factoren spelen een rol?"	- (Hossler, 2004) ^ - Lange & Vierke (2009) *^ - **Langen (2010)** †
Experts working at TU Delft Marketing and TNW Marketing		- **Warps et al. (2010)** † - **Beta Mentality model** † - **Leest, 2011** †

** Relevant because of references; ^Related but not directly useful; †Directly relevant for composing lists of choice and study success factors.*

The bold printed documents market with an † are the documents coming out of this search that were used to make the first list of choice and study success factors.

Literature search for attitudes towards Nanotechnology

A similar exploratory literature search was also conducted for "(high school students) attitudes towards Nanotechnology". See Table 2 below for the outcome of this search.

Table 2.2: Exploratory literature search on attitudes towards Nanotechnology

Database/Search engine used	**Keywords used**	**Main articles/documents found**
Web of Knowledge (Topic search)	"Nanotechnology AND perception AND highschool"	(Scheufele, Corley, Shih, Dalrymple, & Ho, 2009)
Google	"Nanotechnology AND perception AND highschool" produced the Eurobarometer surveys about public attitudes toward nanotechnology in Europe	(Eurobarometer 2010)
My supervisor		Van Est et al. (2004) and Koppeschaar et al. (2011)
By accident		Klop (2008)

The main conclusion from this search was that Nanoscience is still a very unfamiliar subject amongst the general public, but the attitude of those who know something about it is generally positive (Eurobarometer biotechnology 2010; Van Est et al.; 2004, Koppeschaar et al.; 2001, Cobb & Macoubrie, 2004; Hart, 2009). One article pointed out that religious views are correlated to people's view on (moral and) Nanotechnology (Scheufele, Corley, Shih, Dalrymple, & Ho, 2009). No information was found specifically about high school students attitudes towards Nanotechnology. Late in the research the PhD research of Klop (2008) was found and proved very interesting as the research was concerned with high school student's attitudes towards (modern) biotechnology. While it does not directly cover Nanotechnology, (modern) biotechnology is related to Nanobiology. The thesis was useful for reflection and in the discussion chapter I will therefore briefly come back to it.

Because of the unfamiliarity amongst the general public of Nanotechnology and the lack of information on high school student's attitude towards the subject, I decided to use two open questions to gauge student's attitudes towards the term Nanobiology. Nanotechnology was furthermore treated as one of the content elements of the bachelor and not as a separate subject.

Higher education marketing literature search

A keyword search in Web of Knowledge using the words: "Netherlands, higher, education, decision, making, marketing, choice, process(es), model, high school, consumer" in various combinations (see Appendix 2 for each combination and its search results) didn't deliver articles that were relevant enough. Typing in "higher education marketing" in Google Scholar resulted in a review (Hemsley-Brown & Oplatka, 2006) with some very relevant articles, amongst which an article that inspired me to use the method of cluster analysis (Soutar & Turner, 2002). It also resulted in an introduction on marketing higher education (Hayes, 2009). The article by Souter & Turner (2002) lead to more articles on choice factors of high school leavers having to choose a university.

Table 2.3: Exploratory literature search on higher education marketing.

Database/Search engine used	**Keywords used**	**Main articles/documents found**
Web of Knowledge (Topic search)	- Netherlands, higher, education, decision, making, marketing, choice, process(es), model, high, school, consumer" in various combinations.	- Nothing relevant
Google scholar	"higher education marketing"	Hemsley-Brown & Oplatka (2006) *‡. This led to key article **Soutar &Turner (2002)***†.

** Relevant references; ^Strongly related but not directly relevant; †Directly relevant*

While this exploratory literature search led to the most relevant articles, a more thorough literature search was conducted later on, in Web of Knowledge, to compare the results found from the (mostly) grey literature to peer reviewed literature and to see if they fit into a certain theoretical model. The Expectancy-Value model of Eccles et al turned out to be useful as a theoretical framework for choice as well as success factors. Tinto's drop-out model was a bit too general to be directly useful as a theoretical model for the success factors.

Terminology for the survey

I assumed there would be a gap in terms of terminology as well as conceptual understanding, between what high school students learn in their VWO courses and what will be taught in the Nanobiology bachelor. If I would directly use the content elements or concepts that I derived from the analysis of the Nanobiology bachelor, I run the risk that the survey is not understood or wrongly understood by my VWO target group.

To get a first estimate of this gap I consulted the documents describing what 6VWO students should understand at the time of their final exams for the following courses: Physics, Mathematics, Chemistry and Biology (Eindtermen VWO, 2012) . Especially the Biology document helped me to estimate what might be (un)familiar to them.

Additionally, I searched for Biology textbooks used in 5VWO and used a summary of one of these books to estimate what cell-biological concepts and terminology I could use in my questionnaire.

2.3 Qualitative Research Part 2: Analysis of the Nanobiology Program

To compose a list of content elements constituting the Nanobiology bachelor's program, documentation and Collegerama videos in connection with the development and accreditation of the program, were analyzed qualitatively using a process similar to the one suggested by Verhoeven (2008). The process included the following steps:

1) Collecting all potentially valuable documents, presentations and videos describing the Nanobiology bachelor's program. The material analyzed included: the accreditation documents, the material used in (internal and external) information efforts, the videotaped "elevator pitches" (short summaries) given by prospective teachers about the program and the presentation given at the TU delft open days. For a complete list of material used, see Appendix 4.
2) Transcribing the "elevator pitch" and open days presentation videos.
3) Importing documents and transcripts into Atlas Ti.

4) Using open coding to code text fragments that seemed to describe core aspects of the bachelor program. The focus was on content and to a lesser extent on future perspectives, but elements of structure were also included.
5) Organizing the codes by connecting similar codes using Atlas ti and grouping connected codes under a family label. These family labels could be seen as core constructs defining the Nanobiology bachelor's program.
6) Discussing what I found (the constructs as well as the items per construct) with one of the initiators of the Nanobiology program to enhance validity of the constructs and items per construct.

Steps 4-6 deserve some elaboration.

Step 4). Getting hold of the core content elements of the bachelor program was the main focus of the qualitative study. Career perspectives for the prospective students were also important but they were only defined in very general terms in the material used. Fragments describing possible job types were nevertheless coded. Elements of structure that made the program radically different from other programs were also coded. (For example: lessons in English). This was not the focus of the study, but as some of the structure elements were so radically distinctive, I decided together with my commissioner that it would be wrong to omit them. Finally, fragments that didn't describe any of the above were seen as irrelevant and not coded. Personal judgment was used here.

Step 5). I had made interpretations of some of the phrases in the first round already, instead of the pure un-interpreted coding that is recommended for the first round of coding (see for example Verhoeven, 2008 and Baarda & De Goede, 2007). This was done for practical reasons, because of the vast amount of data, but also because I had built up extensive knowledge about the bachelor's program already. In my talks with one of its initiators (David Grünwald) and from my own experience in the Department of Bionanoscience, which is a co-initiator of the program, many of the ideas behind the program were already familiar to me. It didn't make sense not to use this knowledge already in the first round of coding to interpret text fragments.

Step 6). To check for internal validity, I discussed my findings with one of the initiators of the program (David Grünwald) and a professor in Microbiology, see next paragraph. To further increase internal validity I contacted another initiator, Claire Wyman as well, but couldn't reach her in good time. The third most relevant person to contact to increase internal validity, Martin Depken (who took over the responsibilities with regard to the bachelor's program from David Grünwald), gave a presentation during the TU Delft Open Days regarding the bachelor's program. Instead of contacting him I transcribed his presentation and carefully coded this. This served as another perspective on the core aspects of the bachelor program and in this way increased internal validity.

Together with David Grünwald and a professor in Microbiology, Ben Montpetit, we discussed which of the labels I chose made sense and whether the codes under each label rightly belonged there. We also discussed some important labels or concepts that I had missed and added them. All of this led to a few changes. The outcome of this process can be found in Appendices 9 and 11**Fout! Verwijzingsbron niet gevonden.**.

Concluding

The final labels of the code clusters can be interpreted as the dimensions that constitute the Nanobiology program. The table of these labels and the concepts included under them was used as the basis for developing the questionnaire, which is the subject of the next section.

2.4 Instrument Design and Quantitative Analysis

2.4.1 Explorative Research for Preliminary Instrument Design and Testing

Intermediate outcomes from the literature search and qualitative analysis of the Nanobiology program was used to develop a preliminary questionnaire handed out to 24 interested 6VWO students who came to the information afternoons of the bachelor's program. Based on preliminary literature research, only a few program documents and a brief discussion with a peer and my supervisor were used for developing the questionnaire. It also had a large section with open questions. The goal was to get a feeling for what would attract high school students to this program, how they perceive the program and what their attitude is towards a few of the complicated aspects such as "nano", "interdisciplinary" and "societal relevance". It was also an important pretest to find out what type of language they use and understand. Their responses to the questions "what do you find attractive about the Nanobiology bachelor" and "what constitutes the Nanobiology bachelor" were especially enlightening as interdisciplinary terminology was often used by the students. This encouraged me to include interdisciplinary items in the final questionnaire and provided me with terminology that was apparently understandable to 6VWO students.

Choosing terminology for the final questionnaire and translating the core concepts found in the qualitative analysis, to questionnaire items understandable to 5VWO students, was done in cooperation with a high school Physics teacher. The final questionnaire in the making was pre-tested in several ways. A former fellow Bionanoscience student read the questionnaire from both a Nanobiology viewpoint ("Do the items make sense as items representing a bachelor's program that is a combination of Physics and Biology?") and from a former "double profile" student's perspective (i.e. a high school student who chose scientific school subjects representing a physical as well as a biological emphasis: "NT/NG"): "Would the terminology make sense to a 5VWO student with a double profile?". I also tested it with two fellow SEC students who read the questionnaire from a Science Communication perspective ("Does the build-up of the questionnaire make sense, does it have face value validity?"). I added most of their suggestions, which were mostly about being unambiguous and simple in my terminology.

I then discussed it with both my supervisors, and modified it according to their comments. Their comments were mostly about not having more than one element per question. This was important especially in the phrasing of the questions on interdisciplinary aspects. I changed the questionnaire according to their comments. Finally I tested the resulting questionnaire with a girl and a boy, both 5VWO students having a double profile, during their Physics class. At the same time I tested the time required for completing the questionnaire, with two other girls with a double profile . I modified the questionnaire again according to their comments and tested it one last time with an girl with a physical emphasis in her choice of subjects ("NT") . She had only one comment with regard to terminology and I incorporated that. I tested it again with a "non-N profile" girl (e.g. having chosen subjects with an emphasis on languages or economics) for time. It turned out that she needed much more than 10 minutes to complete the questionnaire. I decided therefore to shorten the questionnaire and modified it again. I also checked the final version against my initial qualitative research and brainstorming with David Grünwald and added a few questions that I realized, in view of that brainstorm session, where missing. This result became the final version and wasn't pretested again. It was, however, tested again by double profile and "NT" students when I asked a total of two boys and two girls from the classes that I visited to complete the final questionnaire out loud. Their comments provided insight into the final validity and reliability of the questionnaire. I will elaborate on this in the discussion chapter.

2.4.2 Explorative Research for Preliminary Instrument Design and Testing

Sampling Strategy

To answer the research sub questions 3,5 and 6) a survey was developed and put out with 5VWO students with an NT and/or NG profile. (NT=physical emphasis; NG=biological emphasis.) The minimum number of respondents needed per variable that you want to measure is roughly 25. (Baarda & De Goede 1997.) In the end we're interested in differences between four groups of students, divided with respect to indicators of their success probability (high and low) and indicators of their attractedness to Nanobiology (high or low). We want to measure differences in scores between these groups for one variable at a time. This means we need at least 25 respondents in each group, so a sample of 100 would be the absolute minimum. However, more respondents are definitely needed because the respondents might not be equally distributed amongst the groups. For safety I took a respondent population of roughly four times this big. For doing factor analysis it is also wise to have a sample size of at least 300. (Field, 2005) To make provision for missing values and a response rate below 100%, a sample size of ~450 seemed reasonably safe. A larger sample would become unpractical because of time constraints.

The total population of 5VWO students in The Netherlands with an NT and/or NG profile is estimated at around 20.000 (Internal TNW document, referring to "Tweede Fase Advies Punt" 2010). To have confidence intervals of 5% and a reliability margin of 3% for results based on a sample taken from a population of this size, the sample size should be around 600 (see the table in chapter 6.5 of Baarda and de Goede, 1997). My sample was smaller, for practical reasons. The results are therefore not generalizable to the entire eligible Dutch high school student population with a 5% confidence interval. A sample of ~450 respondents is only generalizable for a population of around 2.000. This may cover the area close to the TU however, which is the most interesting part of the population as they deliver a relatively big part of students to the TU Delft.

As a 'sampling frame' a list was used that provided the mail addresses of the deans of the high schools from which a relatively large number of pupils go to the TU Delft. The list was provided by the client commissioning this research and is normally used by TNW, M&C for their own research and communication. Also from a practical point of view this list was useful as it concerned schools in the region of Delft. All deans from this list were e-mailed with the request to connect me to teachers (preferably Chemistry or Physics teachers) of 5VWO classes with students having an NT/NG profile. Before this list was obtained, four other schools in the region were already contacted through my personal network. The response rate of deans and teachers was 36%. Some offered to distribute the survey themselves during their classes and I sent them the surveys with instructions and the introductory explanation. Others invited me to come and take the survey personally. Surveys were taken at each school that responded positively, at between 1 and 4 classes, each comprising between about 13 and 28 students.

Instrument Build-up and Quantitative Analysis Goals

The questionnaire consists of 5 parts. Quantitative analysis of parts 2 – 5 was done using the Statistical Analysis program SPSS (version 19).

Part 1) consists of two open questions about the word 'nanobiology' and is an exploratory investigation of associations with and attitudes towards the name of the bachelor's program. It is particularly interesting to know this because of the term 'nano'. This is part of the research that should lead to an answer to sub question 3, as 'nano' is one of the (especially hard) constructs that define Nanobiology. The question to be answered is: what might be the effect of the name on the attitude of 5VWO students towards the Nanobiology bachelor's program? In particular, what are their associations with the word 'nano'? The goal is to have a preliminary gauge on high school students' knowledge of and attitude towards the term 'nano' and 'nanobiology'. Answers will be grouped according to the segments its respondents belongs to. This is primarily meant as additional background information for the commissioning client. The results are not included in this thesis for practical reasons.

Part 2A) is the main part of the questionnaire and aims at measuring how attractive the various Nanobiology program (content) aspects and job types are to 5VWO students. (Part 1 about the name is actually a special part of this.) Factor analysis will be used to group the various items into scales. These scales will then represent the major themes constituting the Nanobiology bachelors' program in the minds of the target group. The attractiveness score of each theme will then be compared between the various types of students (i.e. the final segments in the sample population).

Part 2B) consists of questions evaluating all the program aspects at once, as well as questions evaluating all the job type descriptions at once. These questions will be used as overall indicators of how attractive the bachelor program is to (certain groups of) students. Factor analysis will be used to group these questions into a few choice indicators. These choice indicators will then be used to segment the sample population in terms of how much they are attracted towards the bachelor's program (forming the 'x-axis' in the segmentation graph).

Part 3) is meant to measure the importance of each of the choice indicators that are expected to be important in influencing 5VWO students' study choice. These indicators will be the items in the choice indicator scales in Part 2B). It is important for correct interpretation of the overall choice indicators that come out of Part 2B) to know how important each indicator is. The weight of the different choice factors can be estimated if the importance of each indicator is known.

Part 4) is meant to measure the probability of study success and consists of questions about students GPA's (Grade Point Averages) and students self-efficacy. These success indicators will be used to segment the sample population in terms of how high their success probability is for studying this the Nanobiology bachelor's program (forming the 'y-axis' of the segmentation graph).

Part 5) concerns background questions about the students, including: gender, VWO profile, "beta mentality" and future education decisions and desires.

Finally, a cluster analysis is run on all respondents, using the choice indicators on the one hand and the success indicators on the other hand as input variables. The aim of this is to find segments of students that are either attracted or repelled by the program and at the same time either have a high or a low probability of being successful in the program. A comparison between student types (i.e. respondent segments found by cluster analysis) will then be made, of the score of attractiveness in respect of each theme as mentioned in **Part 2A),** . The conceptual model behind these tests is shown below in Figure 2.2.

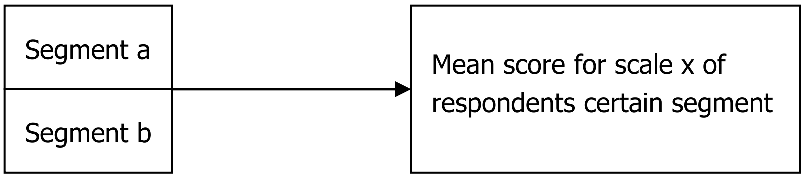


Figure 2.2: Conceptual Model for intended difference tests. For each program theme (i.e. scale) and each job type theme (i.e. scale) the mean scores from the various segments (i.e. groups or clusters) of respondents will be compared and checked for significant differences. One-way Anova followed by post-hoc tests, or independent samples t-tests could be used for this if the data is normally distributed. Kruskall-Wallis tests followed by post-hoc Mann-Whitney tests could be used if the distribution is significantly non-normal.

3 Theory

In the previous chapter it was established that the target group has to be segmented using two constructs: study choice and study success probability with regard to the Nanobiology program. These are complicated constructs. They have to be operationalized into useful indicators that can be incorporated in the final research instrument: the questionnaire. Section 3.1 will give an overview of the literature used to come to a final list of indicators for study choice. Section 3.2 will do the same and conclude with a final list of indicators for study success. Each section will start with a separate introduction and overview.

3.1 Study choice factors: an overview of research

Lots of research has been carried out in the Netherlands into factors influencing the study choice processes of Dutch high school leavers. Because of the problem of a decline in young people's interest in "Beta-Technical"[5] (or "STEM" related) tertiary education and the ever growing need for a workforce educated in this area, attention has also been given to high school students' reasons for *not* choosing "Beta-Technical" tertiary education (Warps et al., 2010; Langen, 2010). A list of choice indicators could already be made using the Dutch literature that was found during the exploratory research phase (see section 3.1.1). The Dutch literature proved most relevant as it concerned the target group of this research. However, to validate the indicators found and place them in a broader scientific framework, a follow up literature search was conducted into the international literature. The Eccles' Expectancy-Value model (Eccles et al., 2002), a key scientific model relating to academic choice and success is discussed together with related research. A reflection of how the choice indicators from section 3.1.1 fit into model and into the related research is given in section 3.1.3. This is a rather complicated subsection because of the complex relation between choice and success that appears. Therefore a brief intermezzo on the relationship between success and choice factors is given in Section 3.1.2. The chapter ends with clear conclusions in Section 3.1.3 summarized in a final list of choice indicators that will be used in this research.

3.1.1 Exploratory research: Dutch literature

University level versus program level

Students make a choice regarding tertiary education at two levels: the institutional level and the program level. Of the general Dutch student population 50% first choose their program and secondly their university. The other half first choose their university and then their program or they choose both at the

[5] "Beta-Technical" is the Dutch version of the expression used to describe the area of Science, Technology, Engineering and Mathematics or "STEM" related subjects and studies. As the meanings of the two terms are slightly different, I will use "Beta-Technical" when talking about Dutch research and literature, and "STEM" when talking about international research, in accordance with their use in the described literature.

same time[6] (Leest, 2011). Concerning the nature of this project and the fact that my commissioning client is Head of Marketing and Communication at the program level and not at the institutional level, I focused mainly on the program level and on factors important on this level. Consequently I focused less on the institutional (or university) level. However, there is quite some overlap in factors influencing university choice and factors influencing program choice, but the importance attributed to each factor at the university level is different from its importance at the program level. For instance, atmosphere is important for choices at both levels, but less important at the program level than at the university level (Leest, 2011, Langen 2010, Broek et al., 2009, Warps 2010). Career possibilities associated with an institution or with a program, however, are important factors at both levels (Leest, 2011, Langen, 2010, Broek et al., 2009, Warps et. al, 2010). The type of programs offered by an institution is in itself an important choice factor at the university level. Research by Soutar and Turner (2002) amongst Australian high school leavers indicated that in choosing a university, the factor "offering a program of interest" is even the most important choice factor. They also quote other research with which this finding is consistent. From now on we will zoom in further on the factors influencing program choice.

Program level

The most important factor influencing program choice in general, according to Biermans (2003), is content. Broek et al., 2009, Langen (2010) and Warps (2010) confirm this by putting the factor "interesting content" first. The latter three all agree on the second most important factor as well: "matching my capacities". Warps researched this for first year Beta-Technical university students (WO) and Langen researched this for 5VWO high school students with an "NT" or "NG" profile (i.e. a scientifically oriented choice of school subjects). Langen has "atmosphere" on the third place followed by "career perspectives" on fourth place and "job chances" on fifth place. With Warps "career perspectives" is third. What comes fourth and fifth also differs between studies, but because Langen (2010) specifically researched the target group that I'm interested in, I will use the factors from her research. However I decided to skip atmosphere entirely as this element is very hard to grasp or predict for a study that doesn't exist yet. Also, this dimension is very different from the other factors. This means "job chances" gets the fourth place.

Warps et al. conclude their research saying that for all tertiary students in general, HBO and WO (college and university), Beta-Technical as well as non-Beta-Technical, the most important motives for choosing their study program are: 1) the program content is more interesting; 2) it matches the capacities and skills of the student better; 3) it offers more or broader career perspectives and 4) it educates towards a career that is attractive to the student. This is slightly different from the general conclusions from Broek et al. (2009), but Warps uses a different and more recent database (i.e. Startmonitor 2008-2009).

Beta choosers versus non-beta choosers

Of the high school population that is eligible to enroll in a technically oriented higher education program, only about 27% does so (Langen, 2010). Considering the growing demand for Beta-Technical educated people, research has been carried out to uncover the factors responsible for this. (for example: Broek et al., 2009; Langen, 2010; Warps, 2010.)

The most important reason given by students who are eligible to enroll in a Beta-Technical type of education but nevertheless choose something else, is that they choose the more interesting study (Warps et al., 2010). The next most important reason is that they don't like the type of jobs that a Beta-Technical education gives access too. Other reasons given are that Beta-Technical education is too theoretical and not societally oriented enough. All of this is consistent with the findings from Langen (2010) and Broek et

[6] Interestingly these percentages are slightly different for the TU Delft. Of the TU Delft population about one third of students first chose their institution and then the program, one third first chose their program and then their institution and one third chose these two more or less simulteneously (Leest, 2011).

al., 2009 . Langen (2010) add to these reasons that Bèta-Technical education is not diverse enough, or too difficult. The latter is confirmed by Van Vonderen et al. (1996).

The factors found are summarized in Table 3.1 below.

Table 3.1: Factors Influencing tertiary education study choice of Beta-Technical eligible students, and factors repelling these students from choosing Beta-Technical education.

Factors influencing higher education program choice	**Factors associated with not choosing Beta-Technical higher education**
Content/Interest	Content/Interest (not interesting)
Fits to capacities	Fits to capacities (too difficult)
Job perspectives	Job perspectives (unattractive)
Job chances	-
	Diversity (not diverse enough)
	Societal orientation (not enough)
	Amount of theory (too theoretical)

3.1.2 Relationship between choice factors and success factors.

Before we can continue with the section on validation of the choice indicators summarized in Table 3.1, a brief intermezzo is necessary to avoid strong confusion. Because: although in this research the topics of study choice and study success factors are treated mostly separately, these topics are off course not entirely independent from each other. In scientific the models there is much interaction and even overlap between academic choice and academic success (for example Lent 1993, 1994). This will become apparent in Section 3.2.2. in the model of Eccles (2002) and the research by Jones (2010). Below follows a brief overview of findings from the international literature, illustrating the relationship between study choice and study success.

Brief overview of illustrations from literature

Bandura (1986) states that "self-efficacy beliefs reflect an individuals' expectations about future performance in specific contexts" (Care et al 2012). And expectations about future success in turn predicts study choice, according to Lent (1994).

Lent, Brown and Hacket (1994) even present "a social cognitive framework for understanding three intricately linked aspects of career development: a) the formation and elaboration of career-relevant interests, b) selection of academic and career choice options, and c) performance and persistence in educational and occupational pursuits," drawing on Bandura's (1986) "general social cognitive theory".

Leeuwerke (2004), hypothesized "that congruence of interest and achievement will account for variance in addition to achievement in prediction of retentions and that achievement and interest congruence will demonstrate an interaction effect". This research on Engineering students in the U.S. indicated that both Mathematics achievement and interest congruence were predictive of students' campus retention (i.e. not dropping out), supporting their hypothesis. They also detected a trend suggesting an interaction effect between Mathematics achievement and interest congruence. Furthermore, Leeuwerke mentions research by Taylor and Hanson (1970) that showed that "achievement differentiated between those who persisted and those who withdrew, whereas interest differentiated between persistence and major change." Additionally, Taylor and Hanson (1972) "demonstrated … some pre-college interest differences between students who persisted in an engineering program and those who transferred to another college".

Patrick (2010) describes "the influence of vocational interest, self-efficacy beliefs, and academic achievement on choice of educational pathway for a cohort of Australian high school students" and found that "all three constructs were significant predictors of pathway and subject selection and enrolment".

Concluding remarks

There are good theoretical grounds for separating, to some extent, the choice and success factors for the purpose of this research. In practice this is also necessary. It is important, however, to keep in mind the relationship between choice and success and their indicators when interpreting the final results. In the discussion chapter I will briefly come back upon this.

3.1.3 Validation research: international literature and theoretical frameworks

Vocational pathways

Choice of higher education is part of the bigger picture in the field of Vocational Pathways. Very important work on understanding vocational pathways at a general level has been done by Holland (see for example Holland, 1997). His model states that an individual's vocational interests are reflected by his/her choices regarding study subjects (Care et al 2012). This model "is widely used to show how patterns of interest underpin students' subject choice in later years of schooling (Care et al 2012)." Patrick (2010) also states that "links between vocational interests and students' choice of educational pathways have been well documented" referring to (Care, 1996; Care & Naylor, 1984; Elsworth, Harvey-Beavis, Ainley, & Fabris 1999). All of this supports the findings in Table 3.1.

Expectancy-Value models and the complex relationship between choice indicators and success indicators

Eccles and her colleagues have done important work focusing on the part of choosing higher education (for example Eccles et al., 1983, 1984, 1987, 2002). Summarizing her own explanation of the model: Eccles and her colleagues tested an expectancy-value model of achievement-related choices, were the relative value and probability of success of various options are key determinants of choice. Expectancies and values are assumed to directly influence performance, persistence, and task choice (Eccles et al., 2002). This model can therefore be seen as offering a broader theoretical framework for the choice and success factors discussed in this chapter. In the rest of this paragraph the link between the constructs in this model, the choice indicators already mentioned and the success factors that will be mentioned in section 3.2 will be researched. A recent version of their Expectancy-Value model, copied from Eccles et al (2002) is shown in Figure 3.1 below. The boxes at the far right, "Expectation of Success" and "Subjective Task Value", directly influencing "Achievement-Related Choices and Performance", are closely related to the choice and success indicators in this research.

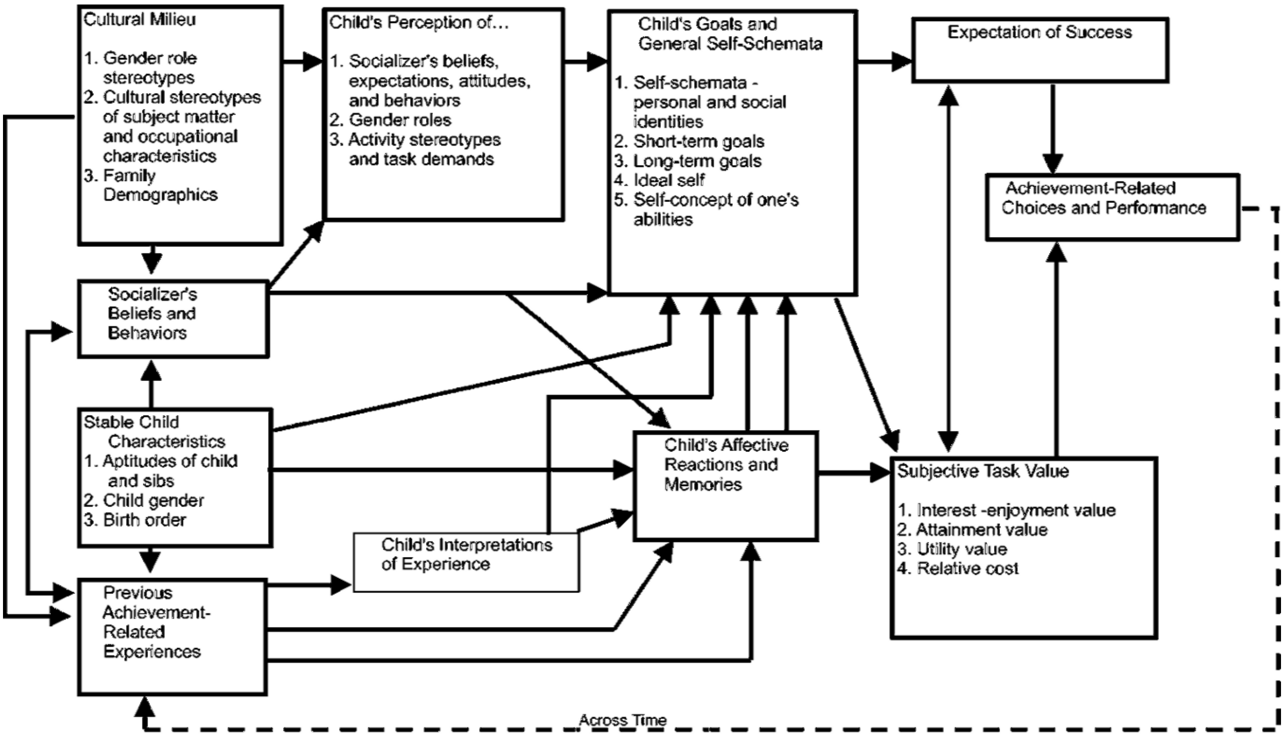


Figure 3.1: The Eccles et al. expectancy-value model of achievement

The expectation of success box could be related to the choice factor "'fits to capacities" (see Table 3.1) as well as the success factors "expecting to graduate" (Table 3.6) and "self-efficacy" (see Table 3.8) that will be mentioned in the next section. The first value from the Subjective Task Value box (lower right-hand side), "interest –enjoyment value" can be related to our choice factor "interest", while the third value in the same box, "utility value" can be related to our choice factors "job chance" and "job perspectives". Intuitively the value "relative cost" could be related to the factor "difficulty" mentioned as a reason for students not to choose Beta-Technological studies. This one is less obvious, though, as a high level of difficulty can also be an incentive to choose the study. A low level of difficulty can become "unchallenging" which is a reason for dropout. It is not a strong one however and will therefore not be further discussed. 'Attainment value' seems to be lacking from our set of choice factors in Table 3.1. It does seem to appear in the items of the scale used to measure "academic binding" by Warps et al (2010). The connection between the Eccles' model and the choice and success indicators in this research are visualized in Figure 3.2 and Figure 3.3 below.

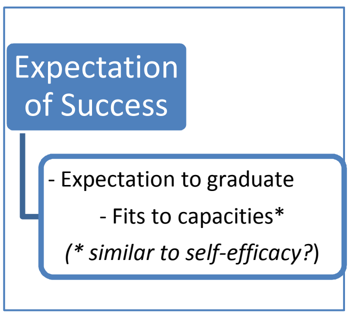


Figure 3.2: Relation between Expectation values in Eccles' expectancy value model of achievement related choices, choice indicators in Table 3.1 and success indicators found in the next section, see Table 3.6.

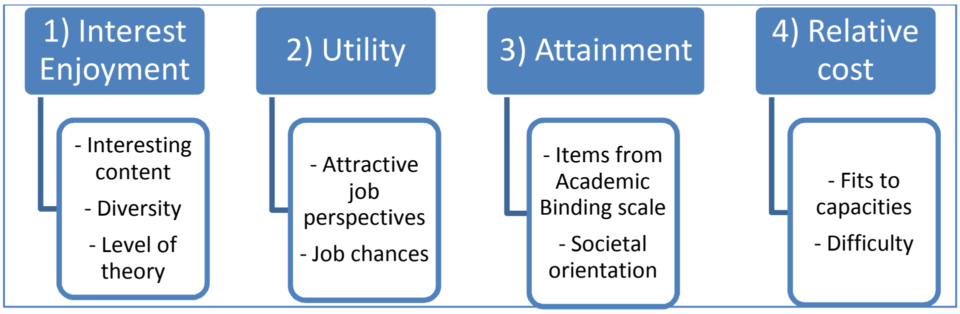
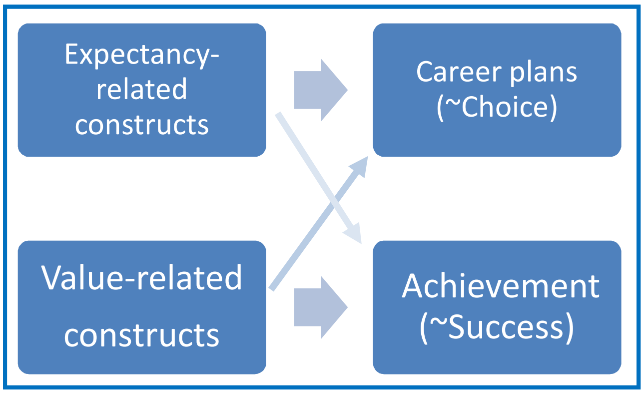


Figure 3.3: Relation between choice factors found in Table 3.1 and subjective task values in Eccles' expectancy value model of achievement related choices.

Boe (2012) uses Eccles et al.'s model of achievement related choices to understand Norwegian upper secondary school students' post compulsory subject choices. Their findings indicate that students choose natural science and mathematics subjects both for identity reasons such as interest, self-realization and fit to personal beliefs, and for strategic utility reasons. Furthermore, girls appear to have placed more weight on utility than on interest. The identity reason 'interest' could be related to the 'interest' indicator in Table 3.1. Strategic utility reasons could be related to the 'job perspectives' and 'job chances' indicators from the same table. The constructs used by Eccles and Boe do differ, however, from the choice indicators found in Table 3.1. Their constructs include notions such as self realization and fit to personal beliefs, which do not seem to be directly related to the indicators in Table 3.1.

Jones et. al. (2010) also mentions Eccles' research and uses expectancy-value theory to study Engineering students' achievement and career plans and their relationships with expectancies and values. Their results indicated that expectancy-related constructs predicted achievement better than the value-related constructs, whereas value-related constructs predicted career plans better for both men and women. There are also cross-correlations however. The pictures below summarizes the idea. They conclude that as the two types of constructs predicted different outcomes, they are both needed to understand students' achievements and career plans in Engineering.



onstructs, careerplans

Jones et al.'s sample population consisted of first year Engineering students in the U.S. The expectancy and value-related constructs were based on Eccles et al.'s model and a factor analysis run on the data, using the computer program SPSS. The expectancy-related and value related constructs that came out were:

Expectancy-related constructs:

E1) Engineering self-efficacy; and

E2) expectation of success in Engineering.

Value-related constructs:

V1) Engineering intrinsic interest value;

V2) Engineering attainment value;

V3) Engineering extrinsic utility value; and

V4) identification with Engineering.

A copy of the complete table with constructs and definitions from Jones et al. is shown below in Table 3.2.

Table 3.2: Expectancy and value related constructs and their definitions. Source: Jones et. al. (2010)

Constructs	Abbreviation	Definition
Expectancy-related constructs		
Self-efficacy theory		
Engineering self-efficacy[a]	Self-efficacy	One's judgment of his or her ability to perform a task in engineering
Expectancy-value theory		
Expectancy for success in engineering[a]	Expectancy	One's belief in the possibility of his or her success in engineering
Value-related constructs		
Expectancy-value theory		
Engineering intrinsic interest value	Interest	The enjoyment one experiences from engaging in engineering activities, or the interest one has in engineering activities
Engineering attainment value[b]	Attainment	The importance of doing well in engineering in terms of one's core personal values
Engineering extrinsic utility value	Utility	The usefulness of engineering in terms of reaching one's short- and long-term goals
Identification with academics		
Identification with engineering[b]	Identification	The extent to which one defines the self through a role or performance in engineering

Note: Constructs designated with the same superscript are conceptually similar.

Not all of Jones et al.'s constructs can be related to the choice and success indicators in

Table 3.4 and Table 3.8 (next section). The value-related constructs 'interest' and 'utility' can be related to the 'interest' and 'vocational choice' factors found. The 'attainment' and 'identification' values, however, are not clearly represented in the tables with summaries of factors found. They are related to items in the scale used to measure 'binding' by Warps et al. (2010). Warps et al. explains 'binding' as "how much students were convinced of their study choice and how much they identify themselves with their educational program and prospective career". Warps et al. measured binding using a scale with many items concerning identification with the program. Items included 'program fits with my norms and values' and 'job type fits with my norms and values', but also 'being very motivated to successfully finish the study', the latter which I would have placed under an expectancy construct rather than a value construct. (The fact that nevertheless the Cronbach's alpha of this scale was very high (0.90) (Warps et al., 2010), confirms the notion that indeed value constructs and expectancy constructs are not uncorrelated. The binding scale however is a too complicated factor to be useful in this research, especially considering the practical constraints that the respondents need to be able to fill in the questionnaire in ten minutes.

Of the expectancy-related constructs, self-efficacy seems similar to the 'fits to my capacities' choice factor. However, self-efficacy is a stronger predictor of achievement than of choice according to Jones et. al.'s research, so it's unclear if the 'fits to my capacities' choice factor should be seen primarily as a choice factor or primarily as a success factor. There is indeed a complex interaction between interest and self-efficacy, which we will touch upon below in discussing research by Care et al. (2011). The "Expectancy of success in Engineering" construct seems similar to the outcome from Broek et al. (2009) that the percentage of students that finish their studies is higher amongst the students that have high expectations with regard to finishing their studies than amongst the students that have a low expectation regarding finishing their studies (see

Table 3.5).

Relationship between self-efficacy and interest

As mentioned before, there is a complex relationship between self-efficacy and interest. Recent research by Care et al. (2011) investigated the relationship between vocational interest, self-efficacy and achievement in the prediction of educational pathways. They did this for all of the six vocational themes established by Holland, known as the RIASEC (Realistic, Investigative, Artistic, Social, Enterprising and Conventional) model. For us the Investigative vocational theme is most important as it includes the subjects Chemistry, Physics, Biology and Mathematics. They found that for the Investigative theme both self-efficacy and grade (i.e. achievement) were significant predictors of choice of educational pathway and that the effect of interest was less strong.

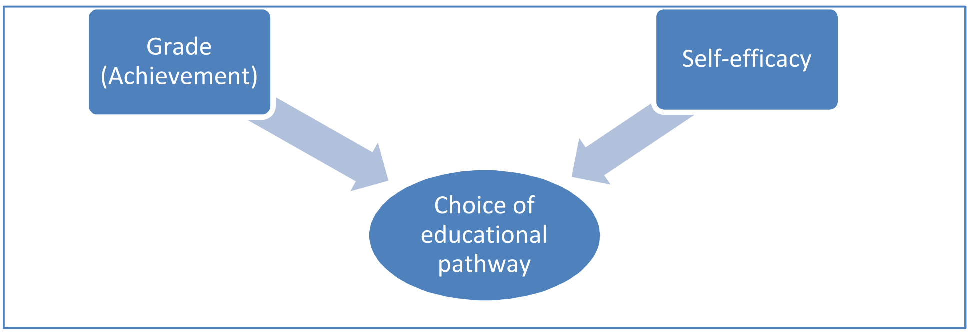


Figure 3.5: Main choice indicators of educational path for investigative students as found by Care et.al. (2011)

The importance of each predictor and its interaction effects with the other predictors were found to vary across the different vocational themes. (For the Realistic theme for example, the interest factor in an interaction effect with self-efficacy was the best predictor of educational choice, making the interest factor more important for Realistic students than for Investigative students). They note that the relationship between self-efficacy and interest is complex and they refer to Betz and Borgan (2000) stating that there is evidence of self-efficacy and interest jointly predicting career choice and of self-efficacy as a causal factor in the development of interest.

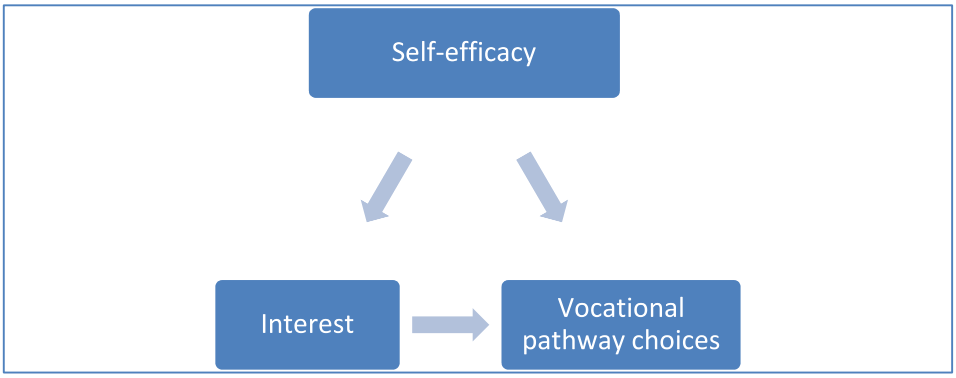


Figure 3.6: Relationship between self-efficacy, interest and choice. Source: Betz and Borgan (2000)

Vocational interest turned out to be a significant (independent) predictor of educational pathway and subject selection for all Holland themes except the 'Enterprising' theme. They refer to previous research with which this is consistent and state that links between vocational interests and students' choice of educational pathways have been well documented. This seems therefore to be a well established choice factor.

The predictor 'vocational interest' could be related to both the 'interest' factor and the 'job perspectives' factor from Table 3.1. The self-efficacy predictor is related to the 'fits with my capacities' indicator found in Table 3.1. Academic achievement is a new choice indicator.

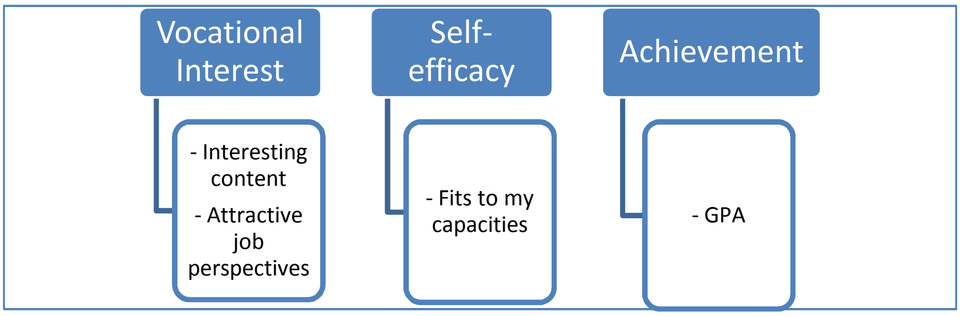


Figure 3.7: Relationship between choice and success factors found in Section 3.1 and choice factors found by Care et al. (2011)

Previous research by Lent et al. (1993) amongst Psychology students in the U.S. also illustrates the complex relationship between self-efficacy and choice. Their results indicated that "the effects of past achievement on course interest were mediated by self-efficacy, and that interests, in turn, mediated the effects of self-efficacy on students' intentions to enroll in mathematics-related choices."

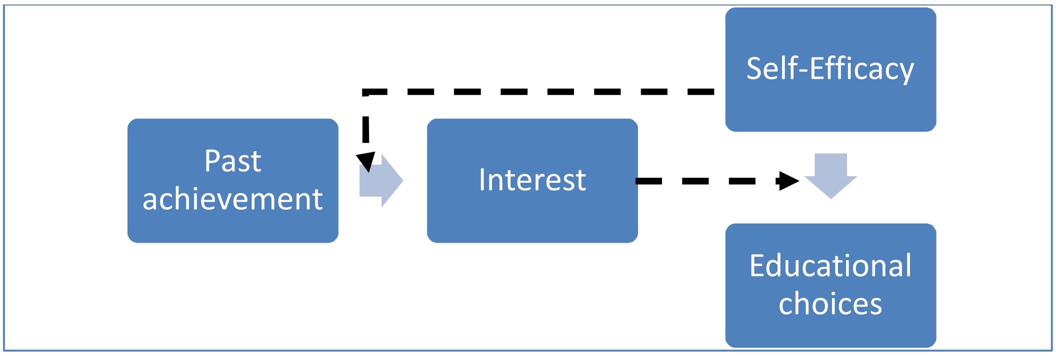


Figure 3.8: Relationships between Past Achievement, Interest, Self-Efficacy and Educational choices as found by Lent et al (1993)

Research by Maltese and Tai (2010) on the other hand, found that students who choose to concentrate their higher education in STEM, make that choice during high school, and that choice is related to a growing interest in mathematics and science rather than achievement. This rends supports again to the high place that the choice factor 'interest' gets in Table 3.1.

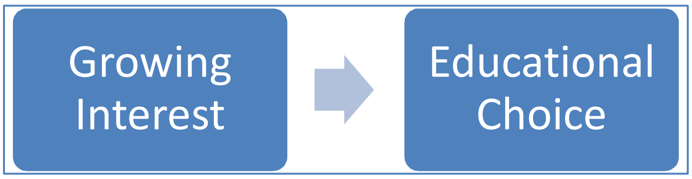


Figure 3.9: Relationship between Interest and Choice as found by Maltese and Tai (2010)

3.1.4 Conclusions for Study Choice Factors

There is support from literature for the choice factors "content interest", "job interest" and "job chances". They can be linked to the expectancy value constructs 'utility' and 'interest-enjoyment value' as well as research from Maltese et al. (2010), Betz and Borgan (2005) and Lent (1993). The factor "fits to my capacities" can be associated with self-efficacy that seems to play a direct role in influencing choice, as well as a mediating role through interest development (Lent 1993). It also seems to be intricately connected to interest, if seen as related to self-efficacy. The societal orientation factor is less obvious but could be related to the subjective task value "Attainment" in Eccles' expectancy value model. 'Theoretical' and 'Diverse' are also less obvious, but could be related to the subjective task value "Interest-enjoyment" from Eccles' model. Table 3.3 below summarizes all in the final list of choice influencing factors.

Table 3.3: Final factors Influencing tertiary education study choice of Beta-Technical eligible students, and factors repelling these students from choosing Beta-Technical education.

Final choice factors	**Link to models from scientific literature**
Content/Interest	Subjective task Value "Interest Enjoyment" (Eccles et al., 2002) Interest → Choice (Maltese and Tai, 2010)
Fits to capacities	Self-efficacy (Lent, 1993) Subjective task Value "Relative Cost" (Eccles et al., 2002)
Job perspectives (type of jobs attractive?)	Subjective task Value "Interest Enjoyment" (Eccles et al., 2002)
Job perspectives (broad opportunities?)	Subjective task Value "Utility" (Eccles et al., 2002)
Job chances (Good chances of finding a job?)	Subjective task Value "Utility" (Eccles et al., 2002)
Theoretical	Subjective task Value "Interest-Enjoyment" (Eccles et al., 2002)
Societal orientation	Subjective task Value "Attainment" (Eccles et al., 2002)
Diversity	Subjective task Value "Interest-Enjoyment" (Eccles et al., 2002)

3.2 Factors Influencing Study Success

Much research has also been carried out in the Netherlands into factors associated with the study success of Dutch students. Again there is particular attention for study success in "Beta-Technical" tertiary education. This time however, the indicators from the Dutch research are less useful for our research while the international literature provided a clear list. The challenge was this time to relate the Dutch literature to the indicators found in the international literature, rather than the other way around as in Section 3.1. Nevertheless, in Section 3.2.1 an overview of the findings from the Dutch literature is presented, starting with literature that focuses particularly on Beta-Technical studies. The findings from this part are then summarized in two tables. More general literature is presented after this, but no new success factors are added to the tables as these were not found. Section 3.2.2 starts by presenting and briefly discussing the main original scientific model on dropout. It then continues by giving an overview of recent international research into study success factors, in particular those related to STEM and engineering students. It concludes by summarizing the indicators found in a list that is much clearer than the lists composed from the Dutch literature. Section 3.2.3 concludes with the final list of choice indicators that will be used in this research.

3.2.1 Exploratory research: Dutch literature

Literature with a special focus on Beta-Technical students

Warps et al (2010) analyzed data collected from a large sample of Dutch first year students (Startmonitor 2008-2009) to understand why students drop out of their studies in their first year. They differentiate between students from Beta-Technical and from non-Beta-Technical HBO (college) programs and between students from technical and non-technical WO (university) studies. I will focus on the numbers given for the students from the Beta-Technical WO study sample. They also differentiate between students that stopped their studies completely and students that switched over to another study program. For both groups the main reasons given for dropout are: "having made the wrong study choice" and "not being motivated enough to continue with this study". The third most given reason is that the study is too difficult.

Follow-up questions on "having made the wrong study choice" reveal that this means that they did not feel good about the study (93%); the study didn't fit their interest and capacities (81%); they didn't really know what they wanted yet (51%); and that they had not oriented themselves sufficiently before choosing and commencing with a study (46%).

Follow-up questions on "not being motivated enough to continue with this study" reveal that this means that they had a wrong picture of the study when they started out on it (70%); they don't feel at home in their study or their university (58%); and they don't have enough contact with their fellow students (25%).

Some follow-up questions were posed only at the the students that dropped out. The students who switched study give as most important reason for this that the expectations they had about the study weren't met, followed at a distance by not feeling at home in the study. The students who stopped their studies give as most important reason for this that they felt they weren't ready for the endeavor of studying yet.

Other findings from Warps et al. are that when comparing persistent students to dropout students in Beta-Technical WO[7] studies, the persistent students more often had as their motive for choosing their study: 1) it's content was more interesting and 2) it gives more attention to developing research skills (see Table 31 in Warps et al., 2010). Strange enough, at the same time when comparing dropouts to persistent students in terms of what they paid most attention to when choosing a study, the dropouts paid more attention to specific program content and courses, and to the exact rules for enrolment eligibility, than the persistent students. So it seems that while dropout students more often pay much attention to the exact content of the program, they base their choice less often on whether or not this content is also interesting! And while persistent students less often pay much attention to exact program content, they more often base their choice of program on whether they think the content will be interesting! A curious paradox, it seems.

Broek et al. (2009) on the other hand concludes that it doesn't really matter with what motive students choose a study, as long as they have a clear motive. Having any type of motive seems to be positively correlated to persistence.

Also, already at the start of their studies, dropout students have lower expectations concerning various aspects of their studies when compared to persistent students. In particular, asking students to express their expectations at the beginning of their first year with regard to how interesting they expect their program content to be, the persistent students had significantly higher expectations (grading it with 8,2 out of 10) than the dropout students (giving it a 7,6 out of 10). Furthermore, a much higher percentage of persistent students expected that they would feel at home in their program when compared to dropout students (93% versus 56%). Broek et al. (2009) also researched the students that dropped out and found

[7] WO stands for "wetenschappelijk onderwijs", i.e. academic ("scientific" in the broadest sense) higher education.

that students' expectation to finish their studies is positively correlated to actually finishing, supporting the findings above.

Warps et al (2010) also used the data from Startmonitor to make regression models by which they could predict dropout based on a few variables. The significant variables with which they could predict dropout for technical WO students starting their studies in September were: lower connectedness with the study (based on a score measured in September); less often having the profile 'concreet beta' (from Beta Mentality); having made less use of intensive information days; more often having concentrated on exact requirements for enrolment eligibility; more often having a handicap or functional constraint. Interestingly, the average exam grades from high school is not one of the variables. From the 5 variables mentioned, 50% of the dropouts could be predicted.

For predicting dropout for students that are a few months into their studies (December-January) the variables changed to: (again) lower connectedness with the study (based on a score measured in September); less often having had the high school profile 'NT' (i.e. physical sciences oriented); lower connectedness with the study (score measured in December); more awareness of certain values ('doing work that adds value, striving for an ideal'); more often having had to repeat a year of study. Interestingly, again high school exam grades are not one of the five variables that make it into the model. Using these 5 variables, 51% of the dropouts could be predicted.

Apart from these documents I had a discussion with my commissioning client where I learned that the TU Delft does use high school exam GPA (Grade Point Average) as an indicator to predict study success. Apparently this is even the most important rule of thumb used by the Department of Physical Sciences to predict study success (expressed in terms of university GPA's, speed of study progress and finally degree attainment). An internal research carried out over 10 years ago confirmed this and results from a current ongoing research confirms this too. They used as a rule of thumb that an average exam grade of 7.0 for Maths and Physics is a good predictor of success.

All these findings on factors seemingly related to dropout are summarized in the two tables below.

Table 3.4: Factors associated with (Beta-Technological) tertiary education dropout

Factors associated with tertiary education dropout
Reasons for dropout: 1) Having made the wrong study choice: - not having a good feeling about the study (93%); - the study doesn't fit interest and capacities (81%); - did not really know what they wanted yet (51%); - no proper orientation before choosing a study (46%).
2) Not being motivated enough to continue with the study: - had a wrong picture of the study when they started out (70%); - don't feel at home in their study or their university (58%); - don't have enough contact with their fellow students (25%)
3) Finding the study too difficult
Reasons specifically for switching studies: 1) expectations about the study weren't met 2) don't feel at home in the study
Reasons specifically for stopping studies: Not feeling ready for the endeavor of studying yet
Regression model predicting dropout students in September - lower connectedness with the study; - less often having the profile 'concreet beta' (Beta Mentality); - having made less use of intensive information days; - having concentrated on exact requirements for enrolment eligibility more often; - having a handicap or functional constraint;
Regression model predicting dropout students in December- January: - lower connectedness with the study (based on a score in Sept.); - less often having had the high school profile 'NT'; - lower connectedness with the study (based on a score in Dec.); - more awareness of certain values: 'doing work that adds value, striving for an ideal'; - more often having had to repeat a year of study

Table 3.5: Factors associated with (Beta-Technological) tertiary education persistence

Factors associated with higher education persistence
Persisters (compared to Dropouts); motivation for study program choice: - content was most interesting - more attention to developing research skills - having any type of clear motivation
Persisters (compared to Dropouts); factors paid attention to in choosing: - Less attention paid to specific program content and courses - Less attention paid to exact rules for admission.
Also, already at the start of their studies, dropout students have lower expectations concerning various aspects of their studies when compared to persistent students. In particular, asking students to express their expectations at the beginning of their first year with regard to how interesting they expect their program content to be, the persistent students had significantly higher expectations (grading it with 8,2 out of 10) than the dropout students (giving it a 7,6 out of 10). Furthermore, a much higher percentage of persistent students expected that they would feel at home in their program when compared to dropout students (93% versus 56%). Broek et al. (2009) also researched the students that dropped out and found that students' expectation to finish their studies is positively correlated to actually finishing, supporting the above.
High school exam grade point average (GPA) > 7.0

Some more general research in the Netherlands

According to Hulst (200?) probably the first large Dutch research into study success was done by the TU Delft ('Technische Hogeschool' at the time) in 1959 (De Groot, 1959). They defined study failure both in terms of dropout and in terms of study delay and tried to identify factors influencing this. They concluded that factors influencing dropout are not necessarily the same as factors influencing study delay.

Prins (1997, 1998) conducted a large-scale research into factors influencing dropout in the Netherlands and distinguished between student related factors and program related factors. For my research the student related factors are the most relevant. Prins stresses though that in the end both student related factors and program related factors have to be considered together if you want to really change the effectiveness of higher education. Prins mentions that the student related factors are different for students studying technical programs and for students studying non-technical programs. In general, high school GPA doesn't play a significant role in dropout. Rather, the most important factors according to him are: motivation, aspiration and self confidence. Prins mentions that for technical programs, however, studies have shown that there is indeed a correlation between GPA and study success. This is confirmed by the findings above. He doesn't go into the details however and doesn't make reference of the particular studies.

Feslö(2000) states that in general, background characteristics of students are hardly related to dropout. Rather, the most important factors for study success are whether the student 'fits' to the study and the students' own perception of their chances of being successful at obtaining their degree. She doesn't differentiate between technical and non-technical studies, however. Her findings seems to relate to attainment value, in particular "binding" as defined by Warps et al., (2010) and to expectation of success, both of which are a part of expectancy-value theory as expectancy-value related constructs.

Feltzer (2009) gives a critical review of literature about the influence of personality traits and other factors on dropout in higher education. Again, she looks at higher education in general and doesn't differentiate between technical studies and non-technical studies. She concludes that personality is a very important predictor of study success. From the 'The Big Five' model, the personality factor 'conscientiousness' is the strongest predictor of dropout versus persistence and correlates positively with persistence. The personality factors 'neuroticism' and 'openness' correlate positively with dropout, but the correlation is weaker than the correlation that conscientiousness has with persistence. Furthermore, academic integration can hinder or stimulate study success. Quality of life also correlates positively with academic achievement. Students with a high quality of life are also more positive, more active and more motivated; all these are facets that are important for study success. Lastly, men have a higher chance of dropout than women, first first year students have a higher chance of dropout than students in later years and students living away from home have a higher chance of dropout than students living with their parents.

3.2.2 Validation research: international literature

When it comes to factors influencing study success, which is commonly described in terms of retention, achievement in grades, progress speed, and eventually attaining a degree, there is a lot of peer reviewed publications that are specific enough to be directly relevant to my research. Again, an overview of factors found will follow at the end of this section.

General dropout model

Because dropout is such a big societal problem, much scientific research has been undertaken into the subject. At a general level, the most notable and perhaps first attempt to begin to comprehensively understand and model the phenomenon 'dropout', was made by Tinto (1975, 1982). He proposed a model based on an extensive literature review. He compared dropout from higher education to suicide and drew upon psychological theories about factors associated with suicide. For example, disengagement from society or lack of binding to society was associated with suicide. He draw the comparison to academic and institutional disengagement and proposed this as a factor influencing dropout. His model served as a base for further empirical research and discussion on the matter ever since. Improvements on this model are still going on. The figure below shows Tinto's original model. The most relevant part of this model is off course the pre-academic part. Tinto wanted to be comprehensive and therefore for the most part this model is too generic to be of direct use to this research. Nevertheless it serves as a valuable theoretical framework to be used for putting this research into a broader perspective.

Also, we can only characterize our population based on pre-academic attributes: family background, individual attributes and pre-college schooling. Family background is too complicated and personal to measure. Of the individual attributes, research has shown that Big Five personality type, self efficacy beliefs and expectancy value beliefs of the individual are important indicators of success. This will be discussed in more detail in the rest of this chapter. Of the pre-college schooling, the most important attributes are: course taking and GPA, especially for VWO science subjects. For reasons that will be discussed in the rest of this chapter I will only use VWO science GPA and self-efficacy as a measure to predict dropout (and academic success)

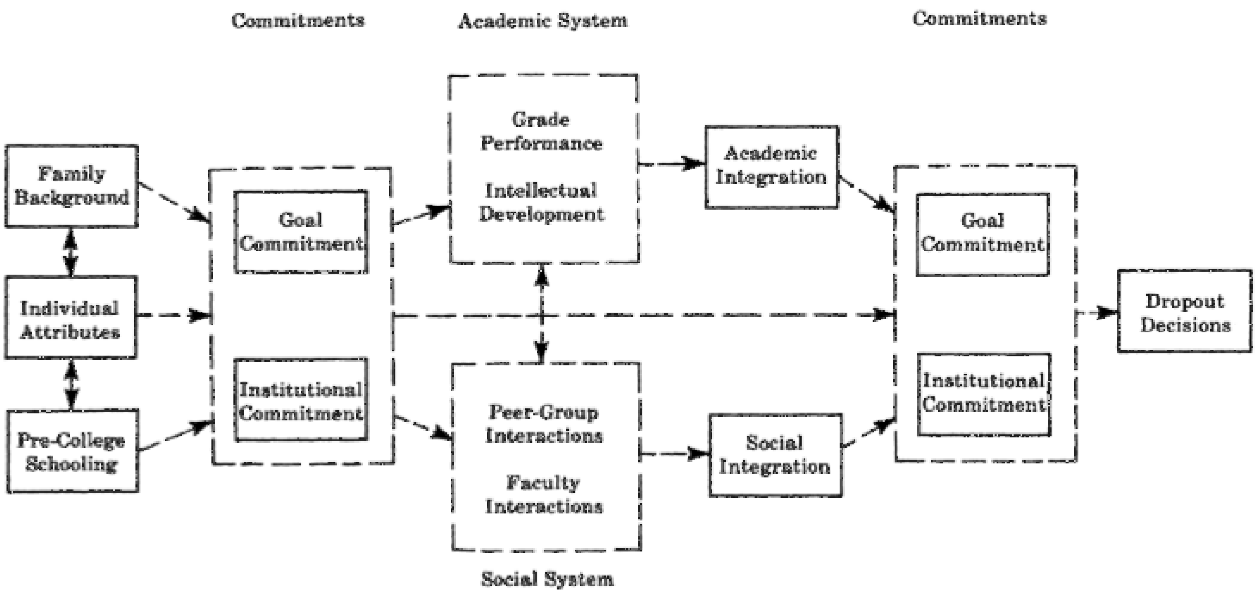


Figure 3.10: Tinto's originally proposed model: Dropout from College (Tinto 1975)

Factors influencing study success: more literature

Much research has been carried out to capture the factors that can be used to predict dropout versus study success. Study success is measured in terms of retention, persistence, academic achievement (GPA) and final degree attainment. Cognitive and non-cognitive factors have been identified in both theory and practice. Success predictors have been found to vary between academic disciplines, in particular between Engineering and other academic disciplines and also between STEM and other academic disciplines.

For example, Veenstra (2008) "explored the differences in predicting academic success (defined as the first year GPA) for freshman engineering students compared to three non-engineering student sectors (Pre-Med, STEM, and non-STEM disciplines) within a university." Researching engineering students in the U.S., they found that "predictors unique to the engineering sector included the factors related to quantitative skills … and confidence in quantitative skills." They also give an overview of factors from a literature review, see Table 3.6 below.

Table 3.6: Overview of factors influencing student persistence and achievement (Veenstra, 2008)

Study/ Reference	Survey	Description	Key Predictors
Levin and Wyckoff 1988	N/A	Freshman engineering study at Penn State	Predictors for first year GPA include: High School GPA, SAT Math, math and chemistry placement test scores, gender and anticipated study time. $R^2 = 0.21$
Astin and Astin 1992	CIRP	Multi-institutional study of 388 universities; looked at engineering majors	For engineering retention: SAT Math, self-rating in math, aspiring to a career in engineering, high school GPA, strong orientation towards science.
Seymour and Hewitt 1997	CIRP/ Study	Includes STEM students from seven universities	Some STEM students indicated that their high school had not adequately prepared them. Engineering majors tend to be more committed to their career choice.
Besterfield-Sacre, Atman, and Shuman, 1997	PFEAS	First term GPA study, University of Pittsburgh	Predictors for first term GPA were: whether student had a scholarship, high school rank, SAT Math, self-assessment of study habits, self-rating of liking math and science and financial influences for an engineering major. $R^2 = 0.29$
Shuman et al. 2003	CIRP	Model whether a student would be placed on academic probation	Frequency in high school of coming to class late, self-rating of academic ability
Lotkowski, Robbins, and Noeth, 2004	N/A	Meta-analysis of 109 College retention studies	For college success (4-year), study found that the high school GPA, ACT assessment and academic self-confidence were strong predictors.
French, Immekus, and Oakes. 2005	N/A	Three-year study. Two cohorts; one to predict college GPA; the second to cross-validate	Predictors for college GPA were SAT Math, high school rank and a measure of academic motivation. $R^2 = 0.18$
Nicholls et al., 2007	CIRP	Compare STEM to non-STEM student with CIRP variables	Predictors for STEM students were SAT Math, high school grades, self-ratings of math ability, academic ability, scientific orientation, going to college to get training for a specific career. Predictors for Non-STEM students were likelihood of changing a major field or career and participating in a study abroad program.

Furthermore, Lent et al. (1993) found that each of 'past achievement' and 'self-efficacy' is a useful predictor of mathematics grades, and furthermore that the effects of 'past achievement' are partially mediated by 'self-efficacy'. They studied 166 Introductory Psychology students to explore the nature of the relationships among 'prior achievement', 'self-efficacy', 'outcome expectations' and 'interest' in predicting students' choice of, and performance in mathematics-related college courses.

Kokkelenberg et al. (2010) examined the characteristics of STEM and non-STEM students for attributes associated with academic success, using student level data from the U.S. They found that amongst others, high school GPA and mathematical ability are significant indicators of academic success.

Ozgur et al. (2010) administered a survey seven times during the course of four years, to a cohort of students who had expressed interest in studying Engineering. They found a correlation between confidence in Maths and Science skills and persistence in Engineering.

Zhang et al., 2004 found that high school GPA and math SAT[8] scores were significant indicators for both graduation and retention in Engineering, for students who enter in an Engineering discipline. They used a database containing all Engineering students of nine universities in the U.S. in the time period 1987 through 2000.

French (2005) researched engineering students in the U.S., trying to predict their academic success and persistence, using cognitive and non-cognitive variables as indicators. The indicator for academic success was their GPA after 6-8 semesters and the indicator for persistence was enrolment at the university and in Engineering after 6-8 semesters. They found that the student pre-college variables, a) SAT score for Mathematics and b) HS Rank (high school attainment relative to peers), were significant predictors of GPA in Engineering. The non-cognitive variables "academic motivation" and "institutional integration" didn't contribute significantly in explaining academic success in Engineering. They mention that this is consistent with previous research (Astin 1993, Zhang 2004, Bordonaro 2000, Noble 1999).

Leeuwerke (2004) found that pre-college students' Mathematics achievement was predictive of retention on campus and within the Engineering major. A large U.S. university database was used and students who intended an Engineering major upon entrance of their first semester of college were included in the sample of over a thousand students.

Tyson (2010) used "high school and college physics and calculus course taking and achievement to predict engineering degree attainment among students on-track for an engineering degree." They used "high school GPA and mathematics standardized test scores to measure pre-college characteristics and first year of college GPA to measure academic integration in college". They found that "high school calculus achievement is the strongest predictor of grades in college physics and calculus courses". They conclude that "engineering degree attainment models should include course taking and particularly achievement in high school and college physics and calculus courses..."

Jones et al. (2010), focusing on Engineering students, note that the factors associated with persistence are complex and not well understood. Researchers have tried nevertheless to get a hold on these factors and Jones et al. give a brief summary of recent research into factors associated with Engineering students' persistence. Researchers found strong correlations between student retention on the one hand and student motivation, student institutional integration and student grade point average (GPA) of the other hand. It also suggests that non-persisters more often enrolled initially because of external pressure (e.g. family pressure) and disengaged from the curriculum (e.g. missing class and not completing homework). Studies also found self-efficacy to be an important factor in engineering students' persistence,

[8] SAT is a certain type of standardized test used in America

achievement, and interest. They note, however, that much more research has been carried out into self-efficacy beliefs of engineering students than into value related beliefs, while the latter may be a more important factor regarding persistence than self-efficacy. Results from their study indicate that indeed value-related constructs are important, especially for predicting career plans, but the expectancy-related constructs which include self-efficacy turn out to be more important factors for predicting achievement than the value-related constructs.

Table 3.7 below summarizes the findings from the literature mentioned above.

Table 3.7: Factors Influencing tertiary education study choice of Beta-Technical eligible students, and factors repelling these students from choosing Beta-Technical education.

Factors associated with study success	Scientific literature source
Predictors unique to Engineering: - factors related to quantitative skills - confidence in quantitative skills	Veenstra (2008)
Psychology Maths students: Mathematics grade predictors - past achievement → Future Mathematics grade - self-efficacy → Future Mathematics grade - past achievement being partially mediated by self-efficacy.	Lent et al. (1993)
STEM vs. Non-STEM: Academic success indicators - high school GPA - mathematical ability	Kokkelenberg et al. (2010)
Students interested in studying Engineering; correlation to persistence in engineering: - confidence in maths and science skills	Ozgur et al. (2010)
Graduation and retention in engineering: - high school GPA - Maths SAT[9] scores	Zhang et al. (2004)
Predictors of academic success in Engineering: Student pre-college variables: - SAT score for Mathematics - HS Rank (high school attainment relative to peers)	French (2005)
Predicting retention within Engineering major: - pre-college students' Mathematics achievement	Leeuwerke (2004)
Grades in Physics and Calculus courses in an Engineering program: - high school Calculus achievement is the strongest predictor of grades in college Physics and Calculus courses	Tyson (2010)
Engineering student retention: - student motivation - student institutional integration - student grade point average (GPA) Engineering students' persistence, achievement and interest: - self-efficacy Engineering students achievement - expectancy related constructs in general	Jones et al. (2010)
Electrical Engineering, TU Eindhoven students GPA VWO Science courses	Dekker (2009)

[9] SAT is a certain type of standardized test used in America

3.2.3 Conclusions for Study Success Factors

To conclude this overview, self-efficacy and GPA seem to be valuable indicators for STEM student, and in particular Engineering student success. They are far from perfect, however, and need to be used with caution. Understanding student persistence and achievement remains a complex matter involving many factors and the interplay between these factors is still not well understood and in need of much more research. The emphasis of the present research is primarily on student choice and the question which (content) elements of the Nanobiology bachelor's program would influence this choice, and less on student success. For practical reasons I therefore had to limit the amount of research that I could do on the side of student success. Nevertheless it is important to have an estimate of student success probability in order to make a segmentation of the target population. Without this segmentation the results from this research would be far less interesting and probably not helpful in informing strategic marketing and communication efforts.

In addition, the department of TNW of the Delft University of Technology has done internal research confirming the link between high school GPA and academic achievement for its students and have been using this rule of thumb in practice for over 10 years. Furthermore, GPA is a relatively easy indicator to measure with high school students, especially compared to indicators such as their 'Big Five personality', but also compared to indicators such as 'institutional binding'. I therefore decided to use Science and Mathematics GPA's combined with self-efficacy in Physics, Mathematics and Biology as estimators of student success probability. I chose these three subjects as these are familiar to (most) students in the target group and the easiest connection between the core content of the Nanobiology bachelor's program and content that the high school students are familiar with. Using a combination of these indicators in this study seemed to be the best combination of a practical, easy and reliable way to give a rough estimate of the potential success probability of high school students intending to study Nanobiology. The table below gives the final set of indicators to be used to gauge student success probability.

Table 3.8: Final success probability indicators to be used in the questionnaire.

Final success probability indicators
GPA in Mathematics and Physics
GPA in Biology (or Chemistry for students who do not take Biology)
Self-efficacy in Mathematics
Self-efficacy in Physics
Self-efficacy in Biology

4 Instrument Design and Analysis

This chapter describes the outcome of the qualitative analysis (Section 4.1), the instrument (questionnaire) design based on this outcome (Section 4.2) and the quantitative analysis of the questionnaire outcome (Section 4.3-4.6). In each section the method used to obtain the results will be briefly described, followed by a summary and brief discussion of the main results. Section 4.3 describes background information of the respondents. Section 4.4 describes the factor analysis and resulting factor scales. Section 4.4 gives the outcome of the normal distribution analysis. Section 4.5 gives the results of the cluster analysis performed on all respondents and compares average scale scores and nominal characteristics between the clusters. An elaborate discussion of the validity and reliability of the results will follow in Section 4.7. The main results necessary for answering the research questions will be summarized in Section 4.8.

4.1 Qualitative Analysis Results

The tables below give a summary of the outcome of the qualitative analysis of what the core (content) aspects of the Nanobiology bachelor's program are. The operationalization of the findings to questionnaire items is also included. For a detailed overview of the qualitative analysis process see Appendices 8-11. For the methods used see section 2.3.

Table 4.1: Outcome qualitative analysis and operationalization to questionnaire items for the content aspects of the program

Nanobiology core content aspects	Operationalization to the questionnaire items
The main course body: - (Applied and Theoretical) Physics - Theoretical physics - (Bio)Chemistry - Mathematics	1) Applied physics 2) Theoretical physics 3) Chemistry 8) Mathematics B 35) Challenging program
Molecular biology	4) Cell Biology 5) Genetics 6) Evolution 7) Medical science
Science	23) Learning to do scientific research really well
Fundamental	16) Fundamental knowledge 19) Fundamental understanding of health and disease
Nanotechnology (as a context for understanding biology)	12) Nanoscience 22) Nanotechnology applied to biology to research how 'life' works
Technical	10) Programming: building a mathematical model of a living organism using the computer 14) Engineering organisms 15) Laboratory work 21) Technical: working with and understanding equipment (such as specialist microscopes)
Interdisciplinary	9) Combining physics, mathematics, technology and biology 11) Understanding Cell Biology using physics 13) Combining research methods from physics and biology 17) Research at the medical/ technological/biological borderline 18) Mathematics based biology and physics 20) Combining physics and biology for health applications 24) Being educated in two scientific cultures 38) Lectures at two universities

Table 4.2: Outcome qualitative analysis and operationalization to questionnaire items

Company: technical or medical, research or alternative	51) Researcher in the pharmaceutical industry 52) Researcher in a technical company 59) Technical commercial staff in a company in the life sciences
Science: technical or medical, research or support staff	49) Scientist at a technical university 50) Scientist at a medical institute 53) Laboratory technician
Bridge builder: within sciences or between science and companies	48) Scientist in new physics, nano-, biomedical border field 54) "Bridge builder" between science and companies 55) "Bridge builder" between scientific disciplines
Alternative possibilities	56) Science journalist 57) Scientific advisor (government) 58) High school teacher

Table 4.3: Outcome qualitative analysis and operationalization to questionnaire for the alternative/structural aspects of the program

Nanobiology alternative/structure aspects	Operationalization to the questionnaire items
New/Innovative: - field	25) Pioneering in a new scientific field as a new type of researcher 29) Contribute to newest biomedical science developments
- program	26) Brand-new program 28) Innovative program 32) Possibility to Contribute to program development
- teaching approach	33) Lots of group work 34) Lots of teacher - student interaction
International	36) Internationally oriented 37) Lectures in English
Defined exit strategy after BSc.	27) Specialist program 30) Specialist laboratory research internship 31) Possibility to enter the job market after the BSc.

4.2 Instrument Design

The questionnaire was build-up as follows:

Part 1) Measured attitudes towards the name "Nanobiology" using:

- Two Open questions on attitudes towards the program name "Nanobiology" (results are handed separately to commissioner, not included in this thesis for practical reasons)

- One closed question on whether the name provokes a positive or a negative feeling.

Part 2A) Measured on a 5 point Likert scale the attractiveness of the various program aspects and job type aspects. The 38 program aspects (question 1-38 on the questionnaire, see Appendix 24) and 12 job type, aspects mentioned in Table 4.1, Table 4.2 and Table 4.3 were used for this.

Part 2B) Measured the attractiveness of the entire program, based on the 38 program aspects and the 12 job type aspects, using the indicators found in the theory (questions 39-47 in the questionnaire, see Appendix 244). -

Part 3) Measures the importance of each of the individual choice indicators (questions 63-71 in the questionnaire, see Appendix 244).

Part 4) Measures the probability of study success using questions about students GPA's (Grade Point Averages) and students self-efficacy (questions 74-76 and 82-85 in the questionnaire, see Appendix 244).

Part 5) Measures background characteristics including: gender, VWO profile, "beta mentality" and intentions regarding technical higher education (questions 86-93 in the questionnaire, see Appendix 244).

4.3 Respondent Summary

4.3.1 Method

The survey was completed by 460 5VWO students from various high schools (Gymnasium, Atheneum and Technasium high schools) in the region of Delft (see Appendix 223 for details of the high schools and the exact number of respondents per school). The survey was handed out and completed during the physics or chemistry lesson. Per school surveys were handed out to 1-3 classes; with a number of students varying from 13 to 58 with NT, NG or NT+NG profiles. The response rate of the students was ~100% as they could complete the form during class under the supervision of either myself or their teacher. Two surveys were excluded as they were completed for less than 33% or showed a suspicious answering pattern (meaning that the same answer was given consistently throughout the questionnaire). Fourteen surveys, containing respondents with either an NT or an NG profile, were not used for practical reasons. Two were not used because the respondents had neither and NT nor an NG profile (they had an EM profile). One was not used because the respondent had visited the Nanobiology information day[10], which put the respondent in a very different starting position compared to the other respondents. Excluding the cases described above the final number of respondents was 440. This number does include surveys with a few missing values. Table 4.4 presents a summary of respondent background information.

4.3.2 Results

Table 4.4: Gender, perceived profile and 'true' profile for the total valid respondent population.

Gender	**Frequency**	**Percent**
Girl	186	42,3
Boy	238	54,1
Missing values	16	3,6
Total	440	100
'True' Profile (deduced from courses marked)	**Frequency**	**Percent**
Double Profile	262	59,7
No Double Profile	177	40,3
Missing	1	0,2
Total	440	100
Profile according to respondents	**Frequency**	**Percent**
NT	145	33,0
NG	128	29,1
NG+NT	155	35,2
Missing	12	2,7
Total	440	100

It can be seen in Table 4.4 above that a large number of students with a double profile seem to be unaware of this. When asked for their grades, they filled in grades for the courses that correspond to a double profile, but when asked about their profile they often fill in a single profile.

[10] Note, this is a different informative activity compared to the open days. During the information day much more detailed and personal information was given about the study compared to the open days. The information day is only aimed at 6VWO students while the open days are aimed at a broader target group, also including 5VWO students.

4.4 Factor Analysis and resulting scales

4.4.1 Method

Table 4.5 shows the themes (scales) constituting the Nanobiology program, based on a factor analysis[11] of 440 respondents scores of 38 items describing aspects of the Nanobiology program.

Factor analysis was done using SPSS v19. The extraction method used was Principal Component analysis, initially based on eigenvalues using Kaisers' criterion[12] with eigenvalue 1 and rotation using varimax. The number of factor scales produced is not independent of the eigenvalue chosen. Therefore the scree plot was also examined. This is another method that independently gives an indication of the correct number of factor scales. The scree plot indicated the same number of factor as the primary analysis.

Initially nine scales came out of the factor analysis. One important result from this was that the intended interdisciplinary scale did not emerge from the factor analysis. Rather, the interdisciplinary terms were either spread out amongst other scales or firmly within a non-interdisciplinary scale.

Items were now put in the scale where they had the highest scores and the Cronbach's alpha for each resulting scale was calculated. Items lowering the Cronbach's alpha of a scale below 0,7 were discarded, as well as items that were alone in a scale. After discarding these items another factor analysis was performed without the discarded items, this time resulting in six scales and somewhat differing scores for some items. The procedure described above was repeated for the new scales. In particular, interdisciplinary terms with a high score in one of the scales where kept there. The six scales were interpreted and titled as follows: "Biomedical/Molecular Biology", "Exact/STEM related", "Unfamiliar/Nanobiology specific", "Innovative/specialist", "Fundamental Science" and "International"

Most terms clearly belonged in a certain scale. Some (interdisciplinary) terms however had high scores (between 0,35 and 0,6) in more than one scale (with differences smaller than 0,2). As these terms didn't necessarily fit best conceptually in the scales where they had the highest score, they were tested (using Cronbach's alpha) in all the scales where they had a high score. If they changed the Cronbach's alpha positively with roughly the same amount in more than one scale and if the term could be interpreted to fit in either of the scales, it was discarded for being too unclear (terms 11 and 13).

Term 25 'Pioneering…' had a higher score in the 'Unfamiliar' scale then in the 'Innovative/specialist' scale and rose the alpha's of both scales somewhat, but as it tilted the 'Innovative/specialist' scale above alpha 0,7 and was intended to fit into that scale it was kept there. Items that lowered the Cronbach's alpha of their scale below 0,7 were also discarded. Items that didn't make it into the final themes (factor scales) are listed underneath Table 4.5. After removing the failing items a final number of six scales with a Cronbach's alpha > 0,7 were left.

Finally, to check whether the factor structure still held after deleting the failing items, a final factor analysis (based on eigen values) was performed on the remaining items. The factor structure didn't fully hold; five instead of the expected six scales came out (the scree plot also indicated the existence of five rather than six scales). Four of the six scales remained the same, but two of the six (Innovative/specialist and Fundamental science) fell into one single factor scale instead of two. The scores for Fundamental science were much lower though than the scores for Innovative, with the exception of 25 'Pioneering…'. As it made more sense conceptually to keep these two scales apart and as both scales had a Cronbach's alpha above 0,700, they were kept as separate scales. Finally, doing a factor analysis forcing six scales, the

[11] This was actually a principal component analysis. According to some this is something different then a factor analysis (Field, 2005)

[12] Kaisers criterion with eigenvalue 1 is said to be rather conservative but to be accurate if the sample size exceeds 250 and the average communality is greater than or equal to 0,6 (Field 2005).

Fundamental science and Innovative/specialist scales did separate again. Below in Table 4.5 the final results.

Factor scores of the scales were subsequently computed by averaging the scores of the items in each scale[13]. Item scoring was performed using a Likert scale running from 1 (negative evaluation) up to 5 (positive evaluation) with 3 being neutral. This scale was preserved thanks to the simple method used to compute the scale scores.

4.4.2 Results

Nanobiology aspect scales

Table 4.5: Themes (or scales) of the Nanobiology program. Themes are based on factor analysis on the list of 38 items describing the (mainly content) aspects of the Nanobiology program. Factor analysis was carried out in SPSS (Extraction method: Principal Component analysis initially based on eigenvalues (Kaisers criterion with eigenvalue 1) and finally on forcing 6 scales; Rotation using varimax). Items from theme's with a Cronbach's alpha < 0,7 or from themes constituting less than two items were discarded. Items not intended to belong in a particular list and with scores spread out over various scales were also discarded. Factors scores are simple averages of the scores of all items in a scale and medians of the scale are calculated from that. Item scoring was done using a Likert scale running from 1 (negative evaluation) up to 5 (positive evaluation) with 3 being neutral.

Factor scales of 38 program (content) aspects[14]					
Biomedical science/ Molecular Biology (α=0,89, Median*=3,29; SD =0,947; N=405;) *4,5,7,17,19,20,29 averaged	**Unfamiliar (Nanobiology specific)** (α=0,83, Median*=3,00; SD = 0,911; N=369) *12,14,15,21,22, 30 averaged	**Exact/ STEM related** (α=0,84, Median*=2,71, SD = 0,879, N=395) *1,2,3,8,9,10,18 averaged	**Innovative/ specialist** (α=0,70, Median*=3,50, SD = 0,722, N=423) *25,26,27,28 averaged	**Fundamental Science** (α=0,70, Median*=3,50, SD = 1,02, N = 431) *16,23 averaged	**International** (α=0,78, Median*=3,50, SD = 1,03, N=431) *36,37 averaged
4) Cell Biology; 5) Genetics; 7) Medical sciences; 17) Research at tech/bio/medical borderline; 19)Fundamental understanding of health; 20) Combining physics and bio for health applications; 29) Newest biomedical science	12)Nano-science; 14) Engineering organisms; 15) Laboratory work; 21) Technical; 22)Nanotech-nology applied to biology; 30) Specialist lab internship	1) Applied physics; 2) Theoretical physics; 3) Chemistry; 8) Mathematics B; 9) Combining physics, math, technology, bio; 10) Programming; 18) Math based bio and physics	25) Pioneering in new science; 26) Brand new program; 27) Specialist program; 28) Innovative program	16)Fundamental knowledge; 23) Learning to do scientific research	36) Internatio-nally oriented; 37) Lectures in English

Items that didn't make it into a factor scale or whose factor scale had a reliability < 0,6:

6) Evolution (this formed a separate scale on its own);

11) Understanding cell biology with physics (interdisciplinary term spread out over various scales);

---

13 Factor scores were also calculated using regression in SPSS and forcing six scales on the final items. For ease of interpretation however, the unweighted averages of the items in a scale were used as factor scores.

14 The terms in the questionnaire were formulated and pre-tested in Dutch; the english translations given in this report are an indication of the Dutch terms intended for understanding, but for readability they are not exact translations and the english terms are not validated.

13) Combining physics and biology research methods (idem, spread out interdisciplinary term);

24) Two culture education: biological and physical sciences (idem, spread out interdisciplinary term);

31) Job market after BSc (in a conceptually unclear scale (with 32) with alpha <0,7); 32) Contributing to program development (in a conceptually unclear scale (with 31) with alpha <0,7);

33) Group work (in a conceptually unclear scale (with 34 and 35) with alpha <0,7); 34) Lots of teacher - student interaction (in a conceptually unclear scale (with 33 and 35) with alpha <0,7); 35) Challenging program (in a conceptually unclear scale (with 33 and 34) with alpha <0,7);

38) Two universities (lowered the alpha of its scale and conceptually didn't make sense there)

It is interesting that the item 'Evolution' formed an entirely separate scale. Apparently the respondents did not connect evolution with the cell biology or biomedical topics at all, meaning they didn't even connect it with for example the item 'Genetics'. It would be interesting to find out how they understand and see evolution and what topics they connect it with, especially as evolution is an important part of the Nanobiology curriculum. When looking at the average score of the item 'Evolution' over all respondents (see Appendix 1) the results show nothing special, it has a score a little above 3, making it neutral to attractive to the average population. It might be interesting to have a closer look and discussion of its boxplot, but this is outside of the scope of this research project. One of the respondents of the open days mentioned evolution as one of the aspects of Nanobiology that was less attractive, while the respondent was very interested in biology in general. It might be worthwhile to further investigate the attitudes and associations that (high school) students have regarding this topic.

What is also noteworthy is that the items "Group work", "Lots of teacher – student interaction" and "challenging program" seem to be associated with each other. Perhaps the idea of having intense academic interaction is related to the idea of a challenging program, while lots of self-study is associated with an easier program. This cannot be directly concluded however as the reliability of the scale was below alpha = 0,7.

Surprising is the link between item 31) "Job market after BSc" and 32) "Contributing to program development". One of the respondents who completed in the questionnaire out loud commented on 31) as following: "yes I would like to have some space to choose my own courses", indicating that this item was understood in a very different manner than it was intended to be understood. One respondent commented on 32) with "yes I think it is important that you can make this decision if you want to". All of this slightly suggests that item 32 might be understood to mean personal, individual freedom regarding the curriculum instead of an invitation to help shape a solid program that is ultimately not intended to be flexible to each individual apart from the minor and the internships.

Finally it is noticed that the interdisciplinary terms didn't make it into a scale of their own. This could either mean that respondents are not familiar with the concept interdisciplinary, or the factor analysis method was not carried out correctly. The first explanation wouldn't be too surprising as high school subjects are organized in a highly disciplinary fashion. One of the chemistry teachers specifically mentioned this. On the other hand, the respondents visiting the information days used terminology in describing what attracts them in the Nanobiology bachelor that was very suggestive of interdisciplinary notions. Comments such as: "combining my favorite courses", "approaching biology from a physics viewpoint" and "it has a boundary with other areas" were abundant. It is possible however that they learned this directly from the communication efforts of the bachelor program: either during the open days or from the website, or even during the hour before they completed the questionnaire on the information afternoons. During the first hour of the information afternoons they listened to a presentation by the program director explaining the core aspects of the bachelor, of which combining physics and biology is clearly one.

It is also possible however that the rotation method used was not ideal. The wish was to have orthogonal factors considering the goal of the research, so orthogonal rotation was used. In view of the interdisciplinary scale however it would make a lot of sense to use oblique rotation which allows for correlation between the factors. This would make it more difficult though in the end to extract content elements that can be used for automatic segmentation in strategic communication. More on this will be discussed in the discussion chapter.

Choice factor scales

Similar to the above, factor analysis was carried out on the list of questions 39 – 47 and 60 – 62; evaluating all 38 aspects of the program and all the job descriptions (48-59) in terms of the choice indicators found in chapter 3. Table 4.6 and Table 4.7 show the results from these factor analysis.

Table 4.6: Nanobiology evaluation scales. Evaluation scales are based on factor analysis on the evaluation questions 39-47 (program) and 60-62 (job descriptions). Factor analysis was carried out in SPSS (Extraction method: Principal Component analysis based on eigenvalues (eigenvalue 1); Rotation using varimax). Items from evaluation scales with a Cronbach's alpha < 0,65 or from evaluation scales constituting less than two items were discarded. Items lowering the Cronbach's alpha of a scale below 0,65 were also discarded.

Program evaluation scales		
Primary choice indicator (program based) (α=0,76, Median=3,00, SD = 0,913, N = 435) 39, 40, 42	**Secondary choice indicator (program based)** (α=0,68; Median=3,67, SD = 0,748, N = 429) 41,43,45	**Secondary choice indicator (job descriptions based)** (α=0,74, Median=3,33, SD = 0,849, N = 433) 60, 61, 62
39) I think a program described by the 38 aspects is *interesting* 40) I think a program described by the 38 aspects *fits with my capacities* 42) I think a program described by the 38 aspects offers me an *attractive career perspective*	41) I think a program described by the 38 aspects offers me a *broad career perspective* 43) I think a program described by the 38 aspects in general offers a *good chance to get a paid job* 45) I think a program described by the 38 aspects is *diverse*	60) Education towards the jobs described represent an *attractive career perspective* 61) Education towards the jobs described represent a *broad career perspective* 62) Education towards the jobs described offers *good chances to actually get a paid job*

I think a program described by the 38 aspects is…:

44) Difficult/challenging (in a scale with alpha < 0,6 together with 47)

46) Societally orientated (lowered the alpha of the program based secondary choice indicator)

47) Very theoretical (in a scale with alpha < 0,6 together with 44)

These three choice indicators make up three of the four separate indicators that were collected from the commissioned exploratory research into why Beta-Technical eligible high school students to don't not choose a Beta-Technical higher education. They are also the ones that fitted less well with the rest of the peer reviewed literature (see chapter 3) so it actually makes sense that they didn't make it into the final choice factors. Only the indicator 'diversity' did make it into one of the factors, so this is the only one factor that does not have a very sound basis from the scientific literature. It makes intuitive sense though that 'program diversity' would be connected with having broad career perspectives and therefore also a generally good chance of getting a job.

The names of the choice factors were chosen in accordance with the importance that respondents gave to the various choice indicators. 39), 40) and 42) received the expected rating of 5 (in a Likert scale from 1-5, 5 being the highest rating). On the other hand 41) and 45) received the little lower average rating of 4. Item 43) 'good job chances' also received the highest rating, but because the job perspectives offered by education in this program are still rather vague, this rating of 5 should be seen in the context that the exact jobs are not very clear yet. The job type evaluation scale should also be seen in this light. The job descriptions are much less clear than the program description, so not too much weight should be given to the choice factor resulting from the score for the job types. Taking all this into consideration, the first scale with items concerning the primary program aspects and whose indicators received the highest rating, got the name were named "primary choice factor" and should be considered as the most important indicator of the program's attractiveness. The other two scales, "secondary choice factor (program based)" and "secondary choice factor (job based)", however, are also important as we have seen that job perspectives, even if not crystal clear, are important choice indicators.

Table 4.7: Nanobiology job type scales. Job type scales are based on factor analysis on the job description questions 48 -59. Factor analysis was carried out in SPSS (Extraction method: Principal Component analysis based on eigenvalues, (eigenvalue 1); Rotation using varimax). Items lowering the Cronbach's alpha of a scale below 0,65 were discarded.

Job type scales		
Technical/Scientific emphasis (α=0,84, Median=2,75, SD = 0,939, N = 425) 49, 52, 54, 55, 59	**Biomedical emphasis** (α=0,80, Median= 2,68, SD = 0,939, N=425), 48, 50, 51, 53	**Alpha direction** (α=0,74, Median=2,00, SD = 1,07, N = 436) 56, 57
49) Scientist at a technical university 52) Researcher in technical company 54) "Bridge builder" science and companies 55) "Bridge builder" between sciences 59) Technical commercial employee at a company that sells equipment to institutions in the life-sciences	48) Scientist in new physics, nano, biomedical border field 50) Scientist at medical institute 51) Researcher in pharmaceutical industry 53) Laboratory technician	56) Science journalist 57) Scientific advisor (government)

58) High school teacher scored highest in the "Alpha direction" scale but lowered it more than 0,1 to well below 0,7 so this item was discarded.

Interestingly 'high school teacher' was also the lowest graded job type by the average population, receiving a meager 2, meaning it is quite unattractive to them. Humorously, one of the respondents that filled in the questionnaire out loud described it like this: "I would hate it if I had to teach a group of teenagers. They're so noisy! Yes even myself, I would definitely not want to be my own teacher!"

It is somewhat surprising that the items 54) and 55), 'bridge builder' ended up in the same scale as the technical science items. It was expected for them to appear in the "Alpha direction" scale together with science journalist and science advisor. Apparently the emphasis was on hardcore science in the minds of the respondents, and less on the notion of bridge builder.

It is also interesting that 48), Scientist in new physics, nano, biomedical border field clearly belonged in the biomedical career scale, despite the words physics and nano used. It could have happened that this border field item had come into the same scale with the bridge builders, but again the notion of interdisciplinarity doesn't seem to play a very concrete role in organizing the items.

4.5 Assumption tests: normal distribution and homogeneity of variance

With a few exceptions, all metric variables were significantly non-normal (z-scores of skewness, kurtosis and difference between mean and median gave values generally well above > 1,96 (Field, 2005); K-S tests gave p-values < 0,00; Q-Q and P-P plots showed divergence from the normal line as well as the histograms for the same variables. See Appendix 13 for K-S test outcomes and an example of a Q-Q, a P-P plot and a histogram for a significantly non-normal variable). All data was therefore treated as non-normal.

I assumed homogeneity of variance, but didn't test this as SPSS doesn't offer the possibility to test this for non-normal data.

4.6 Cluster analysis

In this section the Cluster analysis and results will be presented. Section .4.6.1 presents the general cluster analysis method and the resulting clusters. Section 4.6.2 presents the median scores of each cluster for the clustering variables, the program aspect scales, the job aspect scales and the importance attached to the various choice indicators found in chapter 3, representing the dimensions of program attractiveness. Significance analysis of differences between clusters as well as differences between cluster scores and the neutral values are also presented. Section 4.6.3. presents the nominal cluster characteristics and significance analysis of differences between clusters.

4.6.1 Resulting clusters

Method

To segment the group of respondents in terms of indicators for how attracted they are to the Nanobiology program and how likely they are to succeed in the program, a cluster analysis was carried out according to the method described in Burns (2009). The cluster variables were: the three choice factor scales (primary choice scale (program based), secondary choice scale (program based), secondary choice scale (job based)); the self efficacy scores for Physics, Mathematics B and Biology (questions 74-76 in the survey) and the GPA (Grade Point Average) for Physics and Mathematics B as well as the Biology grade (or the Chemistry grade if the Biology grade was missing). To determine the optimum number of clusters to work with, a hierarchical cluster analysis was first run using Ward's method and applying squared Euclidean Distance as the distance or similarity measure (Burns, 2009). Based on analysis of the coefficients in the agglomeration schedule and the dendogram, either five of eight clusters could be identified. (See Appendix 14 and 15 for last part of the agglomeration schedule coefficients and the dendogram). Two K-means cluster analysis were run, the first forcing 5 clusters and the second forcing 8 clusters[15]. The cluster centers for all clusters resulting from this were analyzed. The K-means method forcing 8 clusters provided a more interesting cluster differentiation with regard to the research question and was therefore selected.

[15] Cluster number = 8, Max iterations = 10, Convergence=0

Results

From the eight resulting clusters three were identified as interesting considering the research question, while the other 5 clusters where grouped together in one "rest" cluster. The resulting four clusters were interpreted and titled as follows:

1) The **dream cluster**: relatively high scores on all the choice factor scales (indicating an attraction towards choosing the program) and relatively high self efficacy and GPA scores for Physics, Mathematics and Biology (indicating relatively high success probability).

-

2) The **risky cluster**: relatively high scores on the choice factor scales (indicating an attraction towards choosing the program) but with relatively low self efficacy and GPA scores for Physics, Mathematics B and Biology (indicating relatively low success probability, see theory).

-

3) The **potential cluster**: relatively low scores on the choice factor scales (indicating a repulsion from choosing the program) but having relatively high self efficacy and GPA scores for Physics, Mathematics B and Biology (indicating relatively high success probability).

-

4) The **rest cluster**: relatively low scores on the choice factor scales (indicating a repulsion from choosing the program) and having relatively low self efficacy and GPA scores for Physics, Mathematics and/or Biology and in most cases for all of them (indicating relatively low success probability).

In Figure 4.1 this segmentation is visualized and Table 4.5.1 gives the cluster centers that resulted from the K-means analysis.

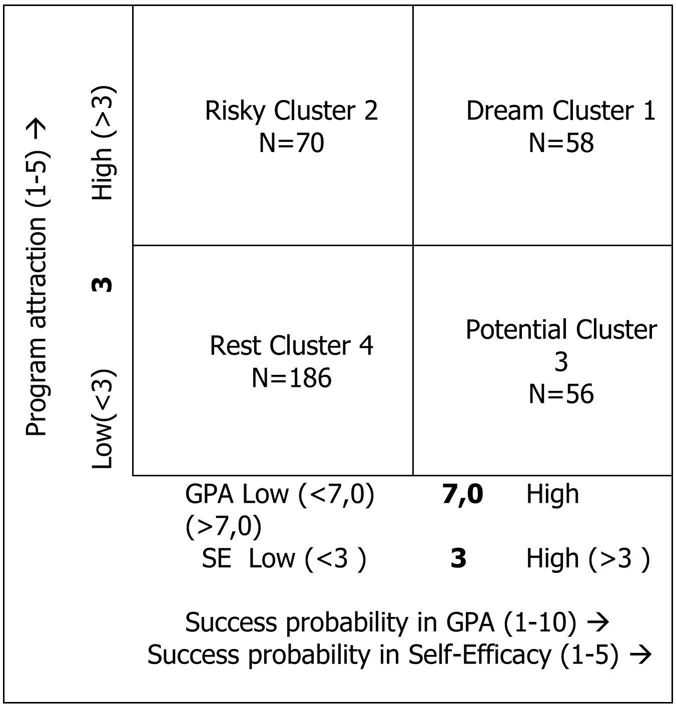


Figure 4.1: Segmentation of sample population in four clusters according to indicators for success probability and attraction towards program. Program attraction indicators were measured on a Likert scale from 1-5 with 1 and 2 being negative, 3 neutral and 4 and 5 positive. Success probability was measured both in GPA's and in self-efficacy for the courses Physics, Mathematics and Biology. Self-Efficacy was closely linked with GPA so that a low GPA correlated with a low self-efficacy and vice versa, see also Table 4.8.

Table 4.8: Final Cluster Centre's resulting from K-means cluster analysis forcing 8 clusters. Original scoring was done one a Likert scale running from 1-5 with 1 being the most negative, 3 being the neutral and 5 being the most positive value. For ease of interpretation, cells with cluster centers with a score around neutral are left colorless, while clear positive scores are made green and clear negative scores are made red.

Cluster Variable	Dream Cluster	Risky Cluster	Potential Cluster	Rest Cluster
Primary choice factor (program based 39,40,42)	**4,01**	**3,60**	3,06	**2,59**
Secondary choice factor (program based 41,43,45)	**4,21**	**4,02**	3,27	**3,42**
Secondary choice factor (job based 60,61,62)	**3,77**	**3,84**	**2,71**	3,01
Self efficacy scores for Physics, (question 74 in the survey)	**4,21**	3,13	**4,21**	3,00
Self efficacy score for Biology (question 75 in the survey)	**4,16**	**4,01**	**4,13**	**2,40**
Self efficacy scores for Mathematics B (question 76 in the survey)	**3,88**	**1,97**	**4,71**	3,00
GPA (Grade Point Average) for Physics and Mathematics B	**7,38**	**6,07**	**7,93**	**6,34**
Biology grade (or Chemistry grade if Biology was missing).	**7,34**	**6,76**	**7,58**	**6,52**

From the Cluster centers we see that the dream group scores positive on all choice and success indicators, which is perfect. The risky group however scores positive on all choice indicators, while they score negative on most success indicators, except for Biology Self-efficacy (positive) and Physics self-efficacy (neutral). Interestingly, the self-efficacy for biology of the risky group (4,01) is quite when comparing it to the actually GPA, especially if you put it next to the self-efficacy of the potential group (4,13), which has almost the same score (4,13) while their biology GPA is almost two points higher than that of the risky group. Relative self-efficacy is however the important success indicator, not absolute self-efficacy.

The potential group is not excited about the types of jobs that Nanobiology seem to give access too, telling from the 2,71 they give the jobs based choice scale. They have a more or less neutral stance however to the secondary job based choice factor and the program based choice factor. So it seems from this their might be hope for recruiting some of these students as it seems they're not entirely negative towards the program.

4.6.2 Cluster median scores and significance analysis.

This section present the cluster medians and analysis of significance in the differences between the cluster medians for the following variables: the three choice factor scales and their overall average, the success likelihood indicators, the program aspect scales, the job description scales and the importance attached to the various dimensions of attractiveness of a higher education program.

Method

Kruskall-Wallis tests followed by Mann-Whitney[16] tests with Bonferonni correction were used to determine significance in the differences in median scores between the three interesting clusters (see Appendix 6-19 for details, summaries are included in the text). Scores were significantly different if they had a $p<0{,}05/4$ corresponding to $p<0{,}0125$[17]. For the most important outcomes, one sample Wilcoxon signed rank[18] tests were used to determine whether medians of cluster scores were significant different from the neutral values. The neutral value for grades and grade point averages (GPA's) was set at 7 while 3 was neutral for all other variables.

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[16] The Mann-Whitney test is a non-parametric analog to the independent samples t-test and can be used when you do not assume that the dependent variable is a normally distributed interval variable (you only assume that the variable is at least ordinal). http://www.ats.ucla.edu/stat/spss/whatstat/whatstat.htm

[17] When doing Mann-Whitney tests after Kruskall-Wallis on variable differences measured between more than two independent groups, the upper limit of the p-value should be divided by the number of independent groups to prevent a pile up of Type 1 error (Field, 2005). This is called the Bonferonni correction. In our case the number of independent groups is the number of clusters, which is four. So for a difference to be significant, the p-value should be lower than 0,05/4= 0,0125.

[18] The Wilcoxon signed rank test is the non-parametric equivalent of the dependent samples t-test.

Kruskall-Wallis test:

Table 4.9: Outcomes of the Kruskall-Wallis tests for significant differences between the 4 clusters: all metric variables that are of interest for the cluster analysis were tested. For details see Appendix 6.

Variable	**Chi-Square**	**Df**	**p-value (Asymp. Sig.)**
Self-efficacy scores for Physics	89,175	3	,000
Self-efficacy score for Biology	112,512	3	,000
Self-efficacy scores for Mathematics B	162,447	3	,000
GPA (Grade Point Average) for Physics and Mathematics B	153,402	3	,000
Grade Point Average of all filled in grades	161,208	3	,000
Biology grade (or Chemistry grade if Biology was missing).	78,654	3	,000
Science/Technically oriented career average	65,269	3	,000
Biomedical scientist career average	65,269	3	,000
Alpha direction (Journalist/Advisor) average	14,139	3	,003
Primary choice scale (program based 39,40,42)	135,746	3	,000
Secondary choice scale (program based 41,43,45)	87,703	3	,000
Secondary choice scale (job based 60,61,62)	99,536	3	,000
Overall average of all choice factors (39,40,41,42,43,45,60,61,62)	169,190	3	,000
BioMed: 4,5,7,17,19,20,29 averaged	63,841	3	,000
Unf: 12,14,15,21,22,30 averaged	60,730	3	,000
Exact: 1,2,3, 8,9,10,18 averaged	51,191	3	,000
Science: 16,23 averaged	27,450	3	,000
Innovative: 25,26,27,28 averaged	29,813	3	,000
International: 36,37 averaged	11,000	3	,012

From the table above it can be seen that there were significant differences in median rating for all the Nanobiology aspect scales found, all the choice factors and all the success indicators.

Wilcoxon signed rank tests:

Table 4.10: Outcome of Wilcoxon signed rank tests for variables with 3 as their neutral score. A value of p < 0,05 indicates a significant deviation from neutral of a cluster median score for a certain variable. A value of p>0,05 indicates that a cluster median score for a certain variable is not significantly different from the neutral value.

Variable	*Does the median of the dream cluster for this variable equal 3? What is the p-value?*	*Does the median of the risky cluster for this variable equal 3? What is the p-value?*	*Does the median of the potential cluster for this variable equal 3? What is the p-value?*	*Does the median of the rest cluster for this variable equal 3? What is the p-value?*
Primary choice scale (program based 39,40,42)	No. p<0,000	No. p<0,000	**Yes.** p<0,336	No. p<0,000
Secondary choice scale (program based 41,43,45)	No. p<0,000	No. p<0,000	No. p<0,002	No. p<0,000
Secondary choice scale (job based 60,61,62)	No. p<0,000	No. p<0,000	No. p<0,014	**Yes.** p<0,866
Overall average of all choice factors	No. p<0,000	No. p<0,000	**Yes.** p<0,532	**Yes.** p<0,248
Self efficacy scores for Physics, (question 74 in the survey)	No. p<0,000	**Yes.** p<0,0238	No. p<0,000	**Yes.** p<0,268
Self efficacy scores for Biology (question 75 in the survey)	No. p<0,000	No. p<0,000	No. p<0,000	No. p<0,007
Self efficacy score for Mathematics B (question 76 in the survey)	No. p<0,000	No. p<0,000	No. p<0,000	No. p<0,050
Biomedical science /Molecular Biology	No. p<0,000	No. p<0,000	**Yes.** p<0,197	**Yes.** p<0,199
Unfamiliar/Nanobiology specific	No. p<0,000	No. p<0,000	**Yes.** p<0,113	No. p<0,000
Exact/STEM related	No. p<0,000	No. p<0,000	**Yes.** p<0,438	No. p<0,000
Innovative/specialist	No. p<0,000	No. p<0,000	No. p<0,010	No. p<0,000
Fundamental science	No. p<0,000	No. p<0,000	**Yes.** p<0,607	**Yes.** p<0,738
International	No. p<0,000	No. p<0,000	No. p<0,000	No. p<0,000
Technical/Scientific career emphasis	No. p<0,000	**Yes.** p<0,453	No. p<0,000	No. p<0,000
Biomedical career emphasis	No. p<0,000	**Yes.** p<0,453	No. p<0,000	No. p<0,000
Alpha direction (Journalist/Advisor)	No. p<0,001	**Yes.** p<0,078	No. p<0,000	No. p<0,000

It can be seen from the table above that for the dream cluster, all median scores were significantly non-neutral, confirming what is shown by Table 4.8 with cluster centers marked green. For the risky cluster all scores except physics self-efficacy, and all three of the job type scales are significantly non-neutral. This corresponds to the neutral colors given in Table 4.8on cluster center scores. It is somewhat strange however that all three career scales get a neutral score, while the career choice factor (secondary choice factor, job based) is clearly positive. So while they aren't particularly attracted to any of the career scales, they are attracted to the general picture given by the career scales, evaluating them as generally attractive, broad and giving a good chance of finding a job.

The potential cluster scores neutral on the primary choice factor, on the (unweighted) average of all choice factor scales and on the program aspect scales "Biomedical", "Unfamiliar", "Exact" and "Fundamental science". Especially the neutral scores for the scales "Exact" and "Biomedical science" is somewhat surprising as these students have high GPA's and high self-efficacy for mathematics and physics as well as for biology/chemistry. It becomes even more interesting now to know the composition of this group in terms of background characteristics. This will follow in section 4.6.3

Table 4.11: Outcome of Wilcoxon signed rank tests for variables with 7 as their neutral score. A value of p < 0,05 indicates a significant deviation from neutral of a cluster median score for a certain variable. A value of p>0,05 indicates that a cluster median score for a certain variable is not significantly different from the neutral value.

Variable	Does the median of the dream cluster for this variable equal 7? What is the p-value?	Does the median of the risky cluster for this variable equal 7? What is the p-value?	Does the median of the potential cluster for this variable equal 7? What is the p-value?	Does the median of the rest cluster for this variable equal 7? What is the p-value?
GPA (Grade Point Average) for Physics and Mathematics B	No. p<0,001	No. p<0,000	No. p<0,000	No. p<0,000
Biology grade (or Chemistry grade if Biology was missing).	No. p<0,003	No. p<0,007	No. p<0,000	No. p<0,000
GPA of all filled in grades	No. p<0,000	No. p<0,000	No. p<0,000	No. p<0,000

All the clusters scores significantly different from neutral on all variables in Table 4.11 above. This makes interpretation of the cluster center scores for these variables easy: scores above 7 are really above 7 and scores below 7 are truly below 7 and not the result of sampling errors.

Comparing median scores of program aspect scales, choice factors and success factors pair wise between clusters:

Figure 4.2 below shows the medians of the three choice factors and their overall average per cluster. All median differences between the three interesting clusters were significant with the exception of a few. Significant and non-significant differences and their corresponding p-values are mentioned at the bottom of each graph. Original scoring was done on a Likert scale running from 1 – 5, with 1 being the most negative score, 3 being neutral and 5 being the most positive score. Because factor scores are not calculated by the refined techniques available in SPSS but simply by averaging[19] the scores of each of the items in a factor, the original scale is preserved.

The first three graphs that follow (Figures 4.2, 4.3 and 4.4) in essence give a summary of the cluster centers from Table 4.8 above and visualize the differences between the clusters. In general the intuitive picture is the correct one: differences that look significant are in general indeed significant and vice versa. There are a few exceptions however. The p-values for all pair wise difference comparisons are given below each graph.

The two graphs that follow then (Figures 4.5 and 4.6) are the really interesting ones as they show how the different clusters score the various program aspect scales, job aspect scales and the single choice indicator items. Scales and choice indicator items that are scored very differently by the dream, risky and potential cluster are the most interesting ones as these could potentially be used in strategic communication using automatic segmentation.

Choice indicators: Choice factors scales

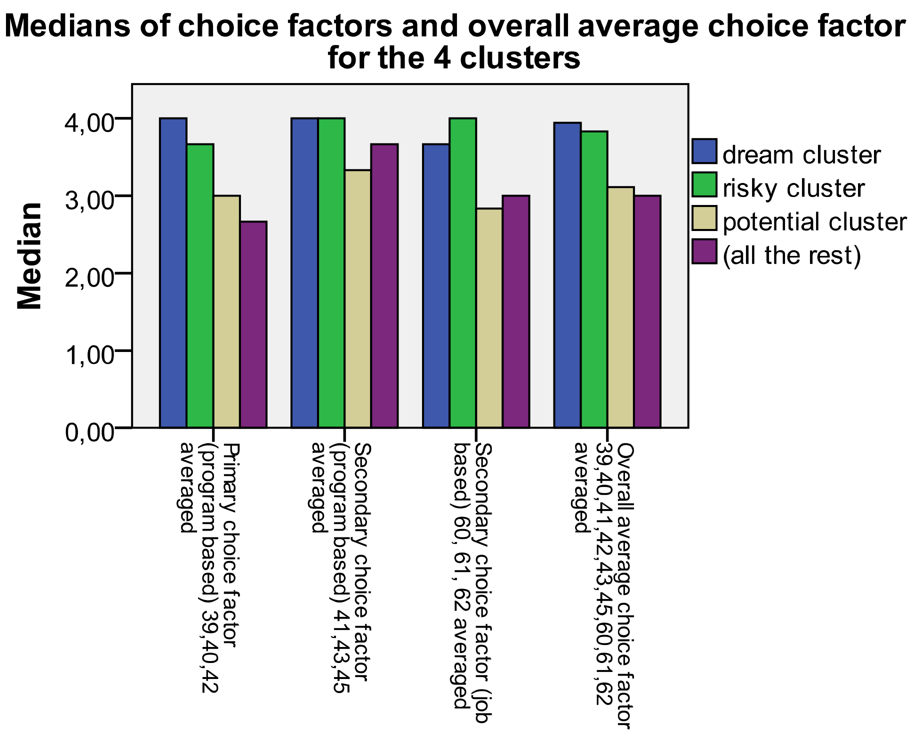

Figure 4.2: Scale medians per cluster for the choice factor scales and their total average. Scoring was done originally on a 5 point Likert scale with 1 being the most negative value, 3 being the neutral value and 5 being the most positive value. Final scale scores were calculated by unweighted averaging of the scores of the items in a scale, in this way preserving the original scale.

Non-significant differences in the choice scales:

- Secondary choice factor (program based): Dream = Risky (p<0,049) (BF: p<0,0125);

- All choice factors averaged: Dream = Risky (p<0,013) (BF: p<0,0125);

[19] This method was also used by Warps et al. (2010) in calculating the 'binding' scores that were calculated using a scale with many items. They simply used the unweighted average of all the single items in the scale to calculate the final scale score.

- Secondary choice factor, job based (Job evaluation): Dream = Risky (p<0,421);

Significant difference in choice scales:

- Primary choice factor (program based)

  Dream > Potential (p<0,000);   Risky > Potential (p<0,000);

- Secondary choice factor (program based)

  Dream > Potential (p<0,000); Risky > Potential (p<0,000);

- Secondary choice factor (job based)

  Dream > Potential: (p<0,000); Risky > Potential: (p<0,000);

- Average of all three choice scales:

  Dream > Potential (p<0,000);   Risky > Potential   (p<0,000);

Success indicators: GPA and self-efficacy

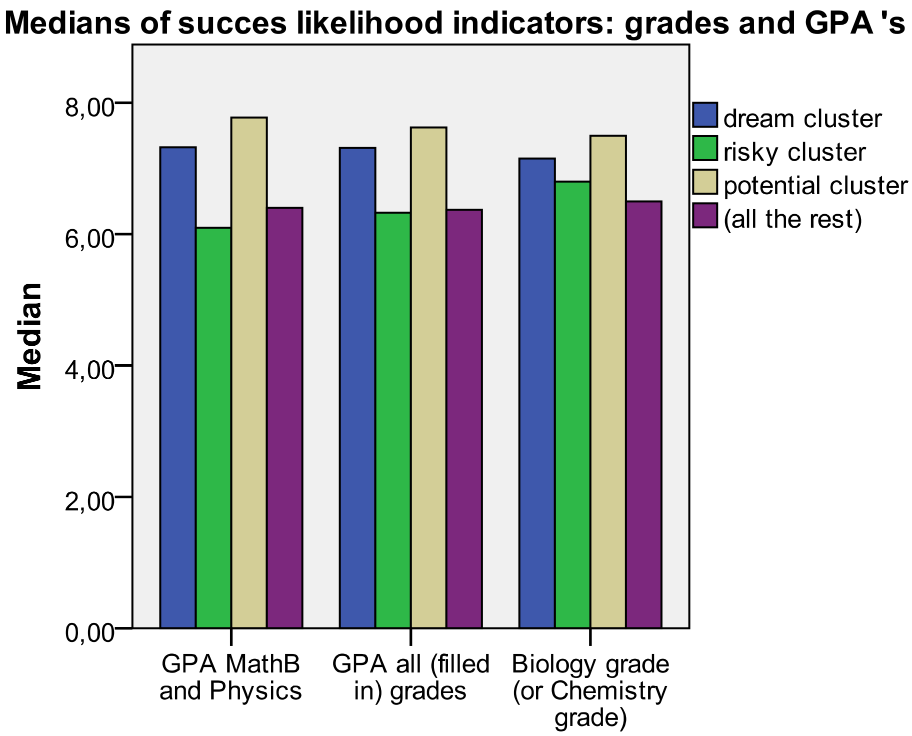

Figure 4.3: Scores per cluster for the success likelihood indicators. Scoring was done originally on a continuous scale with the theoretical range from 0 - 10, 0 being the most negative value, 7 being the neutral value and 10 being the most positive value. Final indicators were calculated as follows: GPA MathB and Physics is the unweighted average of respondents MathB and Physics scores. If a respondent lacked either of the scores, then either the physics or the mathematics grade was used. GPA all filled in grades is the unweighted average of respondents MathB, Physics, Biology and Chemistry scores. If a respondent lacked either of the scores, it was simply left out of the calculation. Biology grade is simply the biology grade, unless a respondent didn't have a biology grade: in that case their chemistry grade was used. The original scales are preserved.

Non-significant differences in the success likelihood indicators (GPA):

- Biology grade: Dream = Potential (p<0,122);

Significant difference in success likelihood indicators (GPA):

- Average of Physics and Mathematics B grade (or Physics grade if there was no mathematics)

Dream > Risky (p<0,000); Dream < Potential (p<0,001); Risky < Potential (p<0,000);

- Average of all grades (up to four) filled in

Dream > Risky (p<0,000); Dream < Potential (p<0,006); Risky < Potential (p<0,000);

- Biology grade (or chemistry grade if there was no biology grade)

Dream > Risky (p<0,000); Risky < Potential (p<0,000);

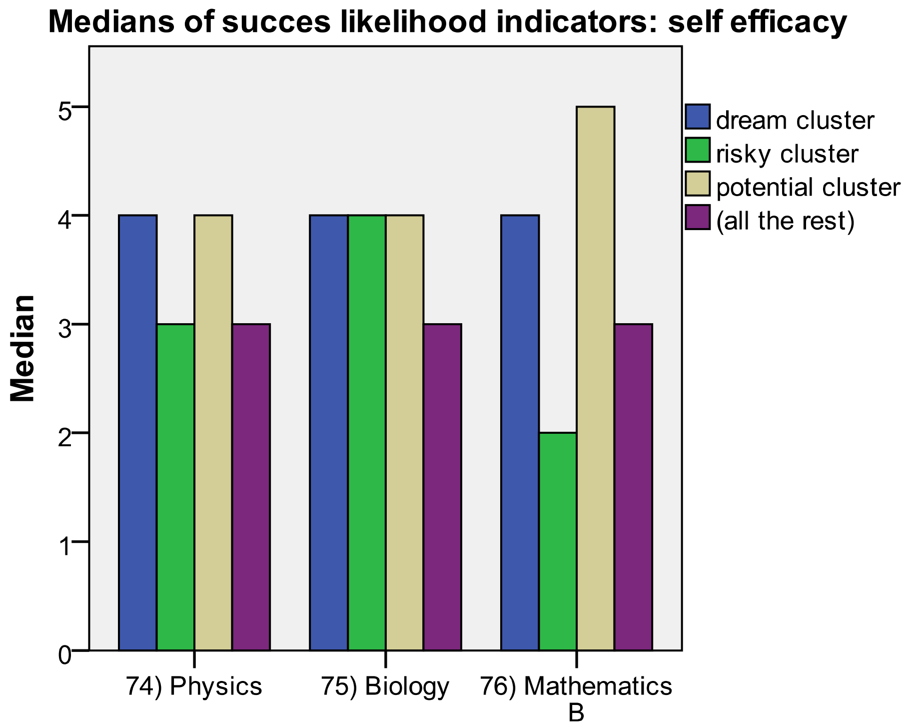

Figure 4.4: Medians of success likelihood indicators: self efficacy

Significant difference in success likelihood indicators (self efficacy):

-Self-efficacy Physics (Q74);

Dream>Risky (p<0,000); Risky < Potential (p<0,000);

-Self-efficacy Mathematics B (Q76);

Dream > Risky (p<0,000); Dream < Potential: (p<0,000); Risky < Potential (p<0,000);

Non-significant differences in the success likelihood indicators (self efficacy):

- Self-efficacy Physics: Dream = Risky (p<0,764)

- Self-efficacy Biology: Dream = Potential (p<0,965); Dream = Risky (p<0,200); Risky = Potential (p<0,280)

Program aspect and job aspect scales:

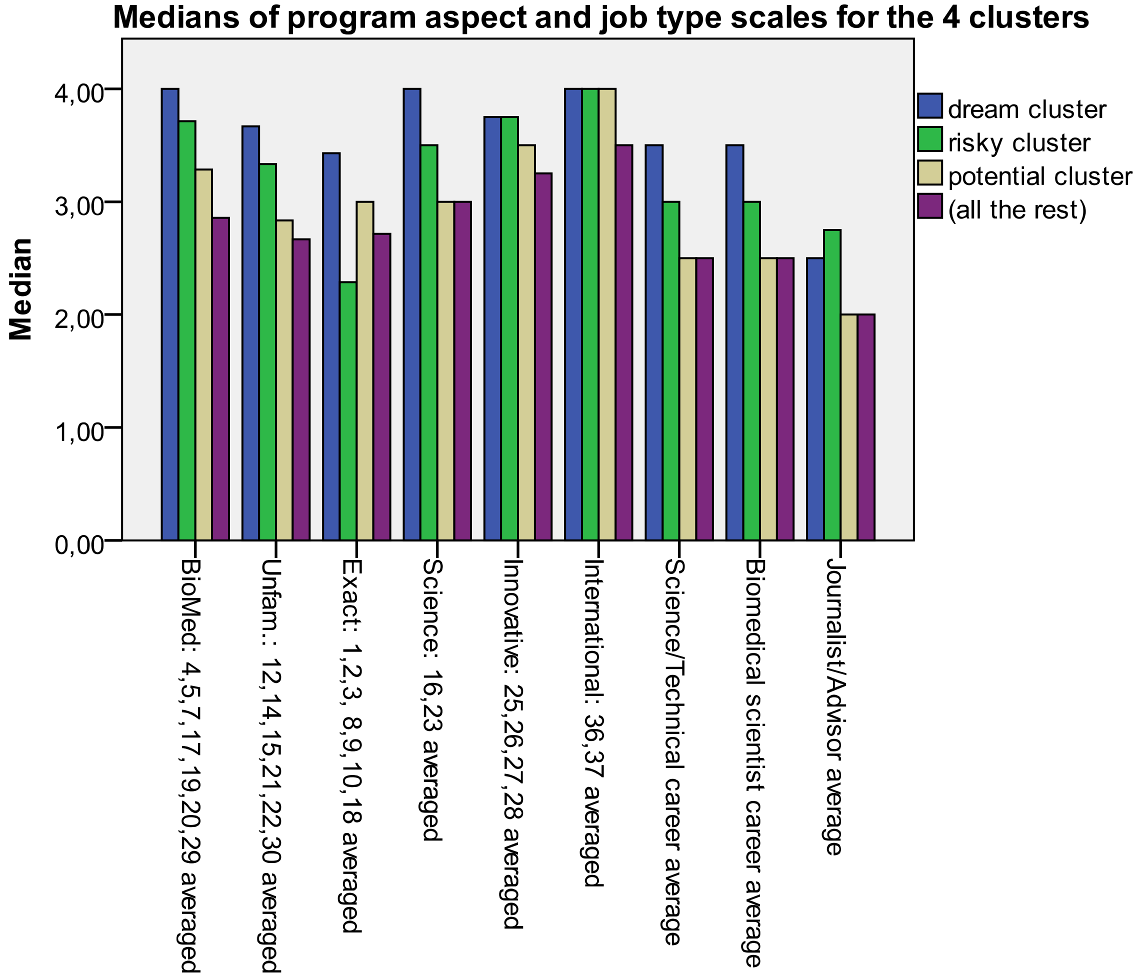

Figure 4.5: Scales scores per cluster for the program aspect scales and the job type scales. Scoring was done originally on a 5 point Likert scale with 1 being the most negative value, 3 being the neutral value and 5 being the most positive value. Final scale scores were calculated by unweighted averaging of the scores of the items in a scale, in this way preserving the original scale.

The list below gives the p-values for the differences between the cluster medians. Most interesting result is the cluster medians for the exact theme: the dream group scores a positive median while the risky group scores a negative mean. The potential group scores neutral on the exact theme. (The Wilcoxon-signed rank test comparing on each cluster group's median to the neutral score '3', as presented in Table 4.10 above, confirms that the dream and risky clusters score significantly different from 3, neutral, $p<0,000$, while the potential group does not score significantly different from neutral $p<0,438$.)

What is also interesting is that no one is very interested in the journalist/advisor career scale. The risky cluster has a neutral stance to it, but the rest gives is a negative score.

On the other hand, everybody is positive about the international aspect.

Finally, it is noteworthy that the dream cluster scores highest and clearly higher than the other clusters on the themes "Biomedical (/Molecular Biology)" and "(Fundamental) Science". They are also positive about the exact scale, be it a little less overwhelmingly. It seems from this that the dream group would indeed fit the study in terms of core content, as it concerns in particular science and a combination of biomedical and exact content.

Non-significant differences in the program aspect and job type scales:

- International: Dream = Potential (p<0,671); Dream = Risky (p<0,284); Risky = Potential (p<0,451)
- Unfamiliar: Dream = Risky (p<0,066);
- Innovative: Dream = Risky (p<0,051);
- Science: Risky = Potential (p<0,185);

- Science/Technical Career: Dream = Risky (p<0,025) (BF: p<0,0125);
- Biomedical Career: Dream = Risky (p<0,025) (BF: p<0,0125);
- Journalist/Advisor career: Dream = Potential (p<0,19); Dream = Risky (p<0,181)

Significant difference in program aspect scales and job type scales:

- Biomedical/Molecular Biology

Dream > Potential (p<0,000); Dream > Risky (p<0,010); Risky > Potential (p< 0,002);

- Exact

Dream > Potential (p<0,006); Dream > Risky(p<0,000); Risky < Potential (p<0,002);

- Science

Dream > Potential (p<0,000); Dream > Risky (p<0,006);

- Unfamiliar

Dream > Potential (p<0,000); Risky > Potential (p< 0,002);

- Innovative

Dream > Potential (p<0,000); Risky > Potential (p<0,009);

- Science career

Dream > Potential (p<0,000); Risky > Potential (p<0,000);

- Biomedical career

Dream > Potential (p<0,000); Risky > Potential (p<0,000);

-Journalist/Advisor

Risky > Potential (p<0,001);

Non-significant differences in the program aspect and job type scales:

- International: Dream = Potential (p<0,671); Dream = Risky (p<0,284); Risky = Potential (p<0,451)
- Unfamiliar: Dream = Risky (p<0,066);
- Innovative: Dream = Risky (p<0,051);
- Science: Risky = Potential (p<0,185);

- Science/Technical Career: Dream = Risky (p<0,025) (BF: p<0,0125);
- Biomedical Career: Dream = Risky (p<0,025) (BF: p<0,0125);
- Journalist/Advisor career: Dream = Potential (p<0,19); Dream = Risky (p<0,181).

Relative importance of each single choice indicator

Table 3.3)

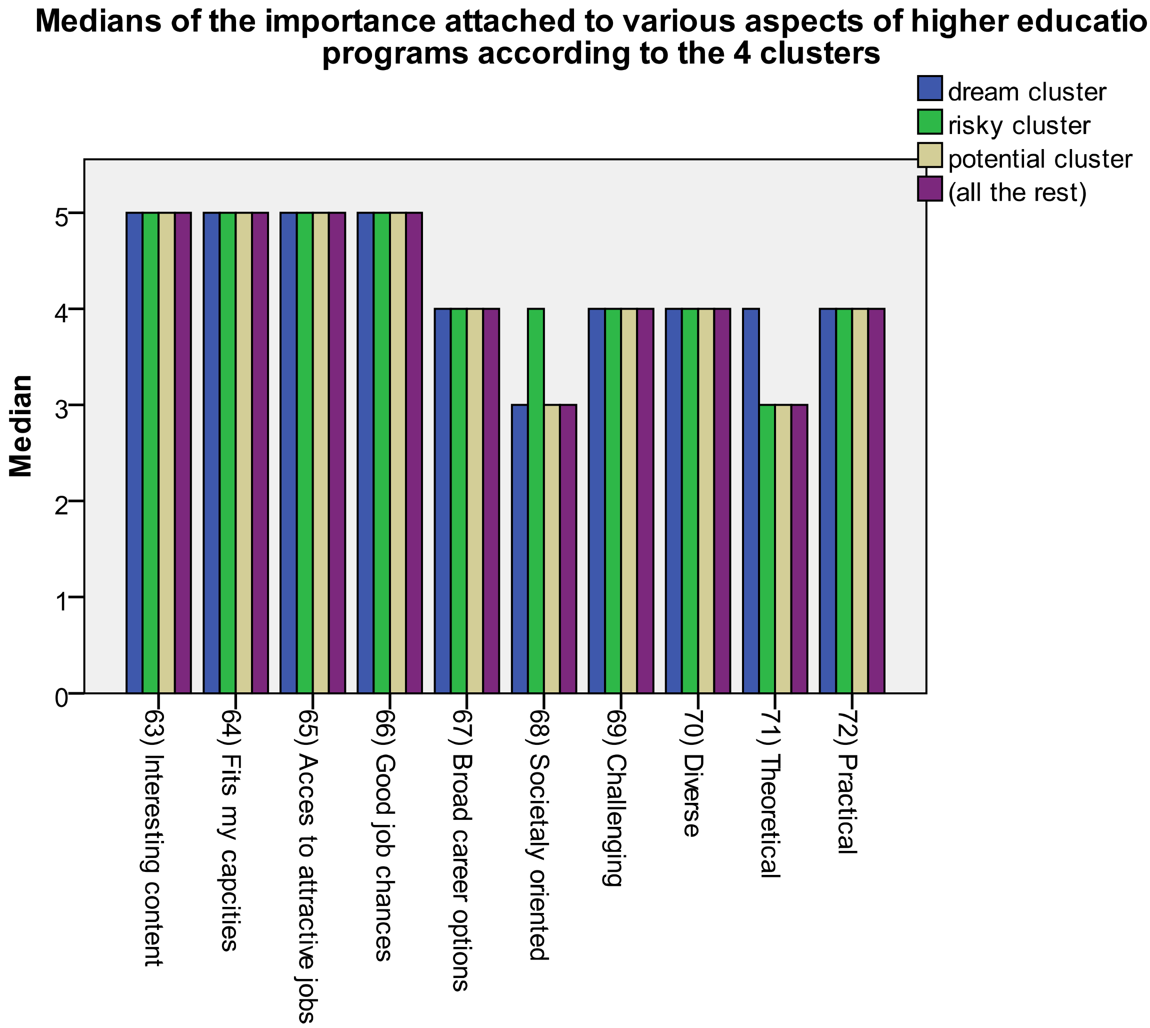

Figure 4.6: Scores per cluster for the single choice indicators found in Chapter 3 (see

Table 3.3). Scoring was done originally on a 5 point Likert scale with 1 being the most negative value, 3 being the neutral value and 5 being the most positive value.

From this graph we notice that most of the single choice indicators have the same weight of importance to all the respondents and therefore cannot be used as an extra tool in strategic communication using automatic segmentation. This does make the communication easier though, as now it is clear that the choice factors have more or less the same weight for different respondents. The only factor that is different is the 'societally oriented' factor, that is more important to the risky cluster than too all the other clusters. This is an important observation, as lack of societal orientation was found (by some of the commissioned research mentioned in Chapter 3) to be a reason for not choosing a Bèta-Technical higher education. If the risky group sees the Nanobiology bachelor as societally oriented, this could become an extra attracting factor, but unfortunately working on the 'wrong' segment of the population. On the other hand, if a respondent from the risky group would enroll in the program and discover at a later stage that there is in fact a lack of societal orientation in the program, this could become an extra factor working against the student's study success. The societal orientation indicator could be connected to 'attainment value', or 'fitting with ones values'. If the program in the end fails to provide the necessary congruence with a students' values, it will work against the success likelihood of this student.
The other interesting observation is that the dream cluster hold the 'theoretical' indicator as more positive than the other clusters. This is again a good indicator, as there is a substantial amount of theory to deal with in the program.

4.6.3 Nominal Cluster characteristics and significant differences in respondent background.

Below follows an overview of differentiating background characteristics of the four clusters. Nominal variables such as gender were cross-tabulated with the cluster number. Significance analysis was done using Pearson Chi-Square and comparison between clusters using the Bonferroni correction. As there were varying amounts of missing values the number of valid respondents 'N' is also given for each nominal variable.

Beta Mentality

There are no significant differences between the clusters with regard to Beta-Mentality, with the exception of the risky and potential cluster for the "Career Beta" mentality. There are significantly less Career Beta's in the risky cluster than in the potential cluster. (Pearson Chi-Square value=25,937; df = 9; p<0,002; N=333)

Gender

There are no significant differences in gender between the 4 clusters. (N=365).

Profile according to respondents

The risky cluster has a significantly lower percentage NT profiles when compared to the rest cluster. It also has a higher NG percentages than all the other clusters. The dream and potential cluster has a lower percentage NG than the risky and the rest cluster. The risky cluster also has less double profiles than the potential cluster, while the potential cluster also has more double profiles than the rest cluster. (Pearson Chi-Square value = 42,151; df=6; p< 0,000; N=369)

Higher education decision

There is no significant difference between the clusters with respect to whether or not they have made a decision regarding a higher education program or not. (N=369)

Positive or negative feelings associated with term 'Nanobiology'

The dream cluster has a significantly higher percentage of respondents with a positive feelings compared to the rest and the potential cluster and vice versa for the negative feeling. There is no difference however between the risky and the dream cluster. (Pearson Chi-Square value = 17,509; df = 3; p<0,001; N=344)

True double profile or not

The dream and potential clusters have significantly higher percentages of double profiles compared to the risky and rest cluster and vice versa for 'no double profile'. (Perason Chi-Square = 49,256; df=3; p<0,000; N=370).

Biology grade (i.e. biology is one of their courses)

The rest cluster has a lower percentage of people with biology as a course compared to all other three clusters. Vice versa, the dream, risky and potential cluster all have a higher percentage of respondents who filled in a biology grade (Question 84) and therefore presumably have biology as a course. (Pearson Chi-Square value = 26,509; df=3; p<0,000; N=370)

Technical Higher Education Intention

The dream cluster has a significantly higher percentage of respondents with the intention of doing a technical higher education than the other three clusters (and vice versa for not having the intention of choosing a technical higher education). The percentage of doubters do not differ between the clusters. (Pearson Chi-Square value = 40,228; df = 6; p<0,000; N=360).

NLT as a choice course

There is no significant difference between the clusters with regard to respondents having NLT as a course or not. (N=370)

Higher Education Types decided upon

Most higher education categories had a too small number of respondents choosing it for doing a reliable Chi-Square analysis. An exception was 'Medicine', mentioned by a total of 58 out of 270 respondents who have already decided what type of higher education they want to follow. No significant difference in percentage amongst the four clusters arose however from the Chi-Square test.

Summarizing the differentiating characteristics found above it follows that:

The **Risky cluster** is different from the Rest cluster in that is has less respondents that filled in NT as their profile and more respondents that take biology as one of their courses. It is furthermore different from the Dream cluster as it has more respondents who filled in NG as their profile, less respondents who truly have a double profile and less respondents with the intention of choosing a technical higher education. Finally, it is different from the Potential cluster in that is has less Career Beta's, more respondents who filled in NG as a course and less respondents who filled in both profiles.

The **Dream cluster** has, apart from the differences with the risky cluster mentioned above, differences with the Potential and the Rest cluster. When compared to the Potential cluster, more respondents have a positive feeling about the term 'Nanobiology' and more respondents with the intention of choosing technical higher education. The Dream cluster is finally different from the Rest cluster in that it has more respondents with positive feelings towards the term 'Nanobiology', more respondents that truly have a double profile, more respondents that have biology as a course and more respondents with the intention of choosing a technical higher education.

Finally, the **Potential Cluster** differs from the Dream and Risky clusters as described above, and it differs from the Rest cluster in that it has less respondents who filled in NG as their profile, more respondents who filled in a double profile and more respondents who have biology as a course.

4.7 Reliability and validity of analysis

4.7.1 Factor Analysis

Sufficient number of respondents?

After running the factor analysis for this research the sample size had decreased significantly (from 440 to 290) due to missing values. For a respondent to be part of the final sample, all items in a factor scale have to be filled in. Even if one item is missing, the factor analysis cannot be run. A respondent number of ~300 is enough though for a reliable factor analysis. Field (2005) quotes Tabachnick & Fidell (2001) that 'it is comforting to have at least 300 cases for factor analysis, and refers to Comrey & Lee (1992) stating that 300 is a good sample size. He also refers to Kass & Tinsley to support this number.

At the same time, the results are formally not generalizable to the entire population. According to Field (2005), Principal component analysis (as well as principle axis analysis) assumes that the sample is the entire population. Results can therefore not be generalized unless a different sample reveals the same factor structure.

Assumptions for data analysis methods met?

Assumptions on the data for factor analysis are: "The data should have a bivariate normal distribution for each pair of variables, and observations should be independent" (SPSS v16). I assumed independent observations as each survey was completed by a unique person. Many variables were however significantly non-normal. Therefore, it would have been better to use Principal Axis factoring as factor extraction method (Boe 2011) as this method does not assume normality of data. It does assume continuity of data while the factor items were scored on a five point Likert scale. However, if ordinal data do not have strong floor or ceiling effects, Likert scales with five categories can be approximated as continuous (Boe 2011 referring to Finney & DiStefano, 2006 and Current, West & Finch, 1996). However, in the end principal component analysis and principal axis analysis usually results in similar solutions (Field 2005).

As the Eccles et al. model predicts choice factors to be correlated, the rotation method for the choice factors should have been one that allows that (see Boe 2011). I used the most common rotation method (varimax) which does not assume correlation between factors.

There are nevertheless good reasons to still trust the results that came out of the factor analysis as their reliability and validity can be evaluated independent of the factoring method. The reliability of the factors that came out were checked using Cronbach's alpha and most factors had high scores of reliability: above 0.7, which is an accepted cutoff point in general (Field, 2005) and also for attitudinal measures (Boe, 2011 and her reference to Gable & Wolf, 1993). Factor loading of items were generally high (above 0,6) and items with unclear loading patterns (spread out or low) were critically evaluated and mostly rejected, as described in the results chapter. Finally, validity of the factors could be checked by examining the conceptual relations between the items in a factor.

Program aspect scales and job type scales

Chapter 4.3 Table 4.5 gives the themes that define the Nanobiology bachelor and Table 4.7 gives the careers it prepares for as understood by the target population. These are:

<u>Content aspect scales:</u> Biomedical/Molecular Biology; Exact/STEM related; Unfamiliar/Nanobiology specific; Fundamental Science;

<u>Job type scales:</u> Technical/Scientific career emphasis; Biomedical career emphasis; Alpha Direction.

<u>Other aspect scales:</u> International; Innovative/specialist;

The scales deserve some discussion. As mentioned before it is interesting that none of the interdisciplinary items came together to form a separate scale. Also, not all of the scale items in the "Unfamiliar/Nanobiology specific" and "Innovative/specialist" scales are directly intuitive. Considering the fact that much of the data is significantly non-normal, while factor analysis has as a general assumption that the data is normally distributed, discussing validity of the resulting factors becomes more important.

The scale 'Innovative' had the item 'specialized' in it. This items should be reconsidered as it doesn't make direct intuitive sense in the theme of Innovation. Because this aspect of the program, being a specialized bachelor, was mentioned by one of its initiators (David Grünwald) in connection with its innovativeness, it made sense to me to leave it in that scale. It is however harder to understand why a high school student would have a similar attitude towards specialization as to innovation. This does not directly devalidate the main results however, as the innovation scale is a less important scale then the program aspect scales with regard to influencing choice. It is however still important to know students' attitudes towards this aspect as it is a distinguishing and important part of the program.

The other scale that deserves to be discussed is the "Unfamiliar/Nanobiology specific" scale. The scale had a high reliability and the items in the scale are all items of which it can be imagined that they are unfamiliar to high school students. Incidentally I found that the items in this scale were all rather specific to the Nanobiology bachelor

The unfamiliar scale did also have the highest number of missing values, 16% versus 2-10%, also somewhat encouraging this scale title. Whether or not the items are indeed quite specific to the Nanobiology bachelor is an interesting discussion. If this is true, it means that it will prove quite a challenge to communicate this distinguishing part of the identity of the program. High school students connect the items in this scale, but it is unclear how they interpret them other than being all very different from what they are used to.

'Interdisciplinary' lacking as a scale

The fact that the very important scale 'interdisciplinary' didn't come out of the factor analysis deserves some attention. Does this result mean that the concept 'interdisciplinary' does not affectively exist as a single entity in the min ds of students? It could be. This could have been expected considering that Dutch secondary education is strongly disciplinary. One chemistry teacher discussed this with me while waiting for his class to come in: "high school students do not have the slightest notion that courses such as physics, chemistry and biology could have anything to do with each other as they are taught completely separate." When asking him if this is different for students following the course NLT[20], he said that even NLT which is supposed to be interdisciplinary in practice is taught in a very disciplinary fashion as each disciplinary module is taught by a teacher from a particular discipline". One might expect that students who have a double profile are more interdisciplinary interested. This might be the case for NT students who also take biology out of interest, especially considering that a lot of NT students express a strong dislike for biology. However, NG students who also have Physics in their package often choose this to keep their career options open rather than out of a real interest in the subject. Many of them want to study medicine and this requires having physics in your package.

For some students the notion of interdisciplinary may exist though. One of the test persons with a double profile who also has NLT as a course remarked that she both likes and thinks she's good at "combining

[20] NLT stands for "Natuur, Leven & Techniek", the most interdisciplinary high school course, intended to make a connection between different (scientific) disciplines.

physics, mathematics and biology" as she always does this in her course NLT and she thinks this is a great course for this very reason!

Furthermore, many of the respondents from the preliminary research, when asked what they find attractive about the Nanobiology bachelor, gave answers in the direction of it being interdisciplinary. Answers like: "combining courses" and "being at a borderline", "combining technology with biology", "the broadness of it, combining all my interests", "combining physics with biology" and other rather interdisciplinary terminology. Though these reasons were given after they had the introduction talk, they all have rather different interdisciplinary descriptions so it does seem to be really coming from themselves and it seems to describe an interdisciplinary interest as a particular motivation to feel attracted to the study. Not just enjoying either or both of the main disciplines, but also the combination! Perhaps the conclusion is that some students do have interdisciplinarity as a notion, but they are too few to make this come out as a separate factor. For a map of all the reasons given for the Nanobiology program being attractive see Appendix 6 and for a map of descriptions given of the Nanobiology program see Appendix 7 (both in Dutch).

The other possible explanation for the non-existence of an interdisciplinary scale is simply that it is (strongly) correlated to some of the other scales, in particular the disciplinary ones. Perhaps using a factor rotation method that allowed for correlation between factors (oblique rotation) would've been better. In that case however problems might arise in finding the program aspects that can be used to send different messages to different parts of the target population, as the whole idea was.

Choice factor scales

As was shown in the theory chapter, the factors that influence high school students' higher education program choice are:

1) Content/Interest;
2) Fits to capacities;
3) Job perspectives (type of jobs attractive?);
4) Job chances (broad opportunities?);
5) Job chances (Good chances of finding a job?);
6) Level of theory;
7) Societal orientation;
8) Diversity;
9) Hard/challenging.

The factor analysis in section 4.4 was run on students' evaluation of the Nanobiology program using all eight terms, as well as on their evaluation of the job types described in terms 3-5, to see which choice indicators belong together. This delivered three choice scales that were used as new variables in the cluster analysis (see Table 4.6 in section 4.3). It is not surprising that the first three indicators came together in one scale. Program interest and vocational based on program content is related according to vocational theory as touched upon in the theory chapter. The theory chapter also showed that 'interest' and 'fit to capacities' are related concepts. The second choice scale, containing the fourth, fifth and last indicators, also makes sense. It is not hard to imagine that high school students could intuitively relate a diverse program to broad future job opportunities. And off course, if the job opportunities are "broader", it is intuitive to think that that would correspond with a "bigger amount" of job opportunities and therefore a "bigger chance" to actually find a job. The third scale, containing the three evaluations of the Nanobiology job descriptions, is interesting. Apparently appreciation for the program content in terms of attractiveness, broadness and anticipated job chances is not directly related to appreciation for the job types described for Nanobiology. If this would have been the case, these indicators would have fallen within the first two

choice scales (3 in scale one and 4,5 in scale two). This is important as it indicates a possible discontinuity between program and future career possibilities. If students are attracted to the program but not the anticipated types of careers, this could make them reconsider enrolment, or worse, reconsider their studies or chosen career path at a stage after enrolment. On the other hand it is also not surprising that the career types evaluation form a separate scale as the program content was described in much more detail than the future careers. Moreover, the 'Alpha Direction' career scale doesn't really fit with the program content, so this could have influenced this divergence between program evaluation and career type evaluation as well.
Finally, an anticipated scale containing the items related to not choosing Beta-Technical higher education, did not emerge. Apparently these indicators are not that strongly correlated with regard to this program. The indicators 6, 7 and 9 were therefore not used in the rest of the analysis. They also generally received a lower importance rating from the respondents than the indicators that did make it into the scales, suggesting that it is not a big loss that 6, 7 and 8 were left out of the rest of the analysis.

The important indicators, with relation to the Nanobiology program, are therefore finally:

1) Content/Interest;
2) Fits to capacities;
3) Job perspectives (type of jobs attractive?);
4) Job chances (broad opportunities?);
5) Job chances (Good chances of finding a job?);
6) Diversity;

4.7.2 Other analysis

Reliability of the study success factors

The final success indicators, as found in the theory chapter are: GPA mathematics and physics; GPA biology (or chemistry for students who do not have biology); Self-efficacy mathematics; Self-efficacy physics; Self-efficacy biology. Table 4.8in section4.6 indicates that there is a correlation between self-efficacy and GPA. A positive self-efficacy for a course corresponds to a relatively good grade, above 7, for this course. This confirms the idea from the theory chapter that self-efficacy and achievement are related but also raises the reliability of both of these indicators. If there would be no apparent relation between self-efficacy and GPA, I would put some question marks behind the reliability of either or both of these indicators. The fact that there is no segment that combines low self-efficacy with a high grade or vice versa is in favor of reliability of the segmentation with regard to the "study success" axis.

p-value chosen for significance

In comparing median scores between groups I used $p<0,05$ to evaluate statistical significance. Perhaps a more conservative $p<0,01$ would be better because I sampled school classes (picked based on teacher response) instead of random students and this implies that the true error is bigger than what is observed in the data (Boe, 2011). In most cases however the value of p was $<0,01$ so I don't expect that it would change the conclusions much.

Clustering method

In the K-means clustering I used the default procedure and I used variables with different scales (5 point Likert scales and 1-10 point grade average scales). It would have been better to use standardized variable scales so it would be good to check in a follow up analysis if the cluster centers change significantly if the GPA's are rescaled to a 5-point scale. Also, I didn't check if the cluster centers changed if I enter the variables in a different sequence. When using the default K-means clustering procedure this might happen and therefore the stability of the solution should be checked (SPSS, v19). Due to time constraints this check has not yet been performed.

Data assumptions

Though non-parametric tests do not assume data to be normal, it does assume it to have homogeneity of variance. I didn't test for this as there is no standard test for this for non-normal data in SPSS. From the little research I did on it, it seemed to be a lot of work and therefore not possible reasons of time constraint. It would be good to check the data for homogeneity of variance in follow up research.

4.8 Summarizing the results to answer the research questions

I) What factors besides 'content' influence higher education study choice of high school students that are eligible to enroll in a Bèta-Technical higher education? And what is the relative importance attached to each of these factors by the target group?

The outcome of the choice factor scales gives the choice indicators that are most important, with relation to the Nanobiology program. These are finally:

Table 4.12: Final choice indicators from choice factor scales

1)	Content/Interest
2)	Fits to capacities
3)	Job perspectives (type of jobs attractive?)
4)	Job chances (broad opportunities?)
5)	Job chances (Good chances of finding a job?)
6)	Diversity

II) What are the core (content) aspects that define the Nanobiology program?

In Chapter 4.3 the themes that define the Nanobiology bachelor are given in Table 4.5 and Table 4.7 gives the careers it prepares for as understood by the target population. Summarizing, these are:

Content aspect scales: Biomedical/Molecular Biology; Exact/STEM related; Unfamiliar/Nanobiology specific; Fundamental Science;

Job type scales: Technical/Scientific career emphasis; Biomedical career emphasis; Alpha Direction.

Other aspect scales: International; Innovative/specialist;

III) What factors influence student success likelihood in higher education programs, in particular, in programs that resemble the Nanobiology program?

The final success indicators, as found in the theory chapter are: GPA mathematics and physics; GPA biology (or chemistry for students who do not have biology); Self efficacy mathematics; Self efficacy physics; Self efficacy biology. Table 4.8 in section 4.6 indicates that there is a correlation between self-efficacy and GPA.

IV) Could emphasis on some of these (content) aspects of the Nanobiology bachelor serve as controls in marketing, to attract students from some segments and repel students from others segments using the exact same marketing material? If so, which aspects should be emphasized?

Figure 4.5 Table 4.5 "medians of the program aspect and job type scales for the 4 clusters" in section 4.6 provides the answer to research sub question IV. To attract the dream student, all the scales except: "Alpha Direction" (Journalist/Advisor), should be emphasized. The only scale however that repels the risky student is the "Exact" scale. Therefore, in order to attract the dream student and at the same time repel the risky student, this scale should be emphasized. Note that this scale is scored neutral by the potential cluster, so this will not help to attract potential students. It is questionable if you really want to attract students from this cluster as they are not attracted to any of the content scales, except for the Biomedical/Molecular Biology scale that gets a slightly positive score. As was mentioned in the theory chapter, interest and success are not uncorrelated and students that have a general disinterest in the program, probably will have a hard time succeeding despite their good grades for science subjects. Moreover, the potential students are repelled by all the career scales and this will not be a motivating factor for them in finishing their studies either. It seems therefore that there is less 'potential' in the potential cluster than I first expected. When looking at the background characteristics that distinguishes the potential cluster from the dream cluster, it is telling that the potential cluster has less students with technical higher education intentions and less students with a positive feeling about the term "Nanobiology" than the dream cluster. This is further indication that students from this cluster are perhaps not a good match with this study and that efforts to encourage them to enroll nevertheless would not be helpful for the program or the student.

V) Are there differences in the relative importance attached to the factors found in I) for different segments of the target population? If so could these be used as additional controls in segmented marketing?

Figure 4.6: "Medians of the importance attached to various aspects of higher education programs according to the 4 clusters" from section 4.6 provides the answer to research sub question V). The important choice indicators (see

Table ***4.12***) all get the same importance weights from all the clusters. The less important choice indicators "societal orientation" and "theory" are scored somewhat different. "Societal orientation" is important to the 'risky cluster' while the other clusters are neutral towards it, and "theory" is important to the dream cluster, while the other clusters are neutral towards it.

With everything mentioned above the research sub questions can be answered as well as the research question, which will be done in the next chapter.

5 Conclusions

In this chapter the main conclusions derived from the Results chapter will be presented in the form of answers to the research question from the first chapter.

Research questions:

I) What factors besides 'content' influence higher education study choice of high schools students that are eligible to enroll in a Beta-Technical higher education? And what is the relative importance attached to each of these factors by the target group?

The final choice indicators, as found in the theory chapter are: Content/Interest; Fits to capacities; Job perspectives (type of jobs attractive?); Job chances (broad opportunities?); Job chances (Good chances of finding a job?); Theoretical; Societal orientation; Diversity.

II) What are the core (content) aspects that define the Nanobiology program?

The themes that define the Nanobiology bachelor and the careers it prepares for as understood by the target population are:

Content aspect scales: Biomedical/Molecular Biology; Exact/STEM related; Unfamiliar/Nanobiology specific; Fundamental Science;

Job type scales: Technical/Scientific career emphasis; Biomedical career emphasis; Alpha Direction.

Other aspect scales: International; Innovative/specialist;

III) Using the answer to I), which (content) aspects of the Nanobiology bachelor could influence the study choice of the target group?

Especially the content aspect scales and the job type scales. How much influence the Innovative/specialist and International scale will have on student choice is not clear. These scales did not turn out to be very interesting however with regard to segmented communication, as they were all rated positively by all the segments.

IV) What factors influence student success likelihood in higher education programs, in particular, in programs that resemble the Nanobiology program?

The final success indicators, as found in the theory chapter are: GPA mathematics and physics; GPA biology (or chemistry for students who do not have biology); Self efficacy mathematics; Self efficacy physics; Self efficacy biology.

V) Could emphasis on some of these (content) aspects of the Nanobiology bachelor serve as controls in marketing, to attract students from some segments and repel students from others segments using the exact same marketing material?

Yes. Emphasizing the "Exact" theme would attract students from the "dream cluster" and repel students from the "risky cluster".

VI) Are there differences in the relative importance attached to the factors found in I) for different segments of the target population? If so could these be used as additional controls in segmented marketing?

No. The most important choice indicators are given the same weight of importance by all respondents. An exception it the "societal orientation" choice indicators that is important to the 'risky cluster' while the other clusters are neutral towards it, and "theory", which is important to the dream cluster, while the other clusters are neutral towards it.

Finally, to answer the question that was posed at the beginning of this thesis can be answered.

Research question; *In order to contribute towards preventing dropout in the future Nanobiology student population, by a) encouraging prospective students with a high probability to be successful in the program, to consider enrolment, while b) discouraging prospective students who have a low probability to be successful in the program, from enrolment: which information elements about the Nanobiology program should be emphasized in communication with high school students?*

The results indicate that emphasizing the program content related to the "Exact" theme in information about the Nanobiology program can contribute towards the goal of preventing dropout. By emphasizing content aspects of the Nanobiology bachelor that belongs in the "Exact" theme, the dream students who seem to have a high probability to be successful in the study will still be attracted, while the risky students who seem to have a low probability to be successful in the study will be repelled. This will hopefully benefit both the program and the student.

6 Discussion

6.1 Generalizability of the results

In this research a method was developed for uncovering the true elements of a bachelor's program that should be emphasized when informing high school students about the program, in order to attract the 'right' student. This is a type of honest communication that is at the same time strategic. Considering what was mentioned in the introduction, that dropout from higher education is a global problem and therefore a problem many or even most higher education program face, the generalizability of the method is an important question. Could the method developed be used by any higher education institution to uncover which information they should emphasize in their communication in order to attract the 'right' kind of students? In this way enabling honest communication that is at the same time strategic? I think the method is in principle totally generalizable. However, as will be described below in section 6.5, depending on the communication goal of a message, certain attributes of the population become important and segmentation of the population can be done based on these attributes. If the communication message of a university is very different or if the target population is very different, other attributes besides "likeliness to enroll in a program" and "likeliness to be successful in the program" might be important. But even if they are the same, these attributes have to be operationalized to indicators. This operationalization will vary depending on characteristics of the program and characteristics of its target group. As discussed in the theory chapter, high school GPA for science and mathematics courses is a proper indicator for success in STEM related studies, in particular engineering. However, this is not a good indicator for success in most other studies, as was also mentioned in the theory chapter. High school science grades are presumably a very bad indicator for dropout from an arts college, but it is probably also a bad indicator for dropout from language programs. Similarly, the indicators for 'likeliness to enroll in a program' might not be 'content/interest', 'fits to capacities' and 'career perspectives' for any kind of target group. In certain cultures 'what the respondents parents want' or 'what the respondents parents did' might be a much more reliable indicators for 'likeliness to enroll in a program'. Therefore, I would say, on an abstract level the method is generalizable. But the operationalization from communication goal to communication message could deliver different attributes useful for segmentation of the population. And operationalization from these attributes to useful indicators will deliver different indicators dependent on the characteristics of the program (such as the scientific field it educates in) and characteristics of the target population (such as culture).

6.2 Reflection on theory

Expectancy Value theories and the potential controversial nature of Nanobiology

In this research the emphasis was on gauging the high school student target populations interest in the Nanobiology bachelor and mapping this out against a rough estimate of their success probability. This was done in order to inform marketing and communication activities aimed at matchmaking between students and this new program: in other words, encouraging the enrolment of students that would 'fit' the bachelor program and therefore be both successful in the study and contribute to its establishment. To estimate student success probability I used a rough measure of self-efficacy and GPA of their STEM courses, which can be related to the 'expectancy' part of Expectancy-value theory. Comparing all this to Expectancy-value theory, I notice that the value side is more complex than what has been addressed by this research. Theory suggest that value indicators are very important indicators of persistence. Especially with an emerging and potentially controversial science such as Nanobiology, the value part could be crucial and attention should be given to this. The role of controversy in defining values is not that important at the level of high school students and is therefore less relevant at the time of recruiting students. Controversy will start to play a bigger role however as students' sense of value develop and change throughout university. Considering the potentially controversial nature of some elements of Nanobiology, such as engineering life (organisms), synthetic biology, and the Nanotechnology theme in general, students' value development throughout their studies could significantly influence their persistence both in the study itself and in their later careers. Perhaps an extra course should be added to the curriculum to address this potential issue.

Furthermore, it would be beneficial for the development of the field of Nanobiology to not only have excited science and technology optimists (Koppeschaar et al., 2011) in the study, but also students critical towards the field. Especially when considering matters of engagement of science and society, one should be wary of a gap emerging between science and technology optimists who are at the same time the experts in the fields, and the critical people who are outside of the professional field. This would hinder the development of a balanced dialogue of this emerging field as well as critical assessment of it and acceptance of it amongst society.

Klop (2008) researched attitudes of high school students towards (modern) biotechnology and found that students who were better informed, adapted their beliefs towards more balanced ones, both the critics and the optimists. It seems therefore that it would be beneficial for the general debate on Nanobiology, if students from both the optimistic and the critical sides were educated in this new scientific field, forming a diverse group of the future experts. This could prevent the formation of a gap between scientists and industry one the one hand and "the rest of society" on the other hand.

The PhD research of Klop (2008) was furthermore very interesting as the research was concerned with high school student's attitudes towards (modern) Biotechnology. Nanobiology forms a part of modern biotechnology and references from this thesis lead to very interesting articles concerned with the topic of (high school students) attitudes towards modern Biotechnology. Most of the concepts discussed in these articles, such as xenotransplantation, were far from a direct relation to Nanobiology. Some however came closer to concepts that are Nanobiology related: genetically modified plants and animals are off course related to the topic of genetically modification in general and this is important in Nanobiology. Therefore this type of research could provide a starting base for a future research more focused on the controversial side of Nanobiology.

6.3 Reflection on "Higher Education Marketing"

There is a common misunderstanding regarding marketing, which is that it is mere advertising and often giving out promises that cannot be met in reality. According to the American Marketing Association, however, "Marketing is an organizational function in a set of processes for creating, communicating, and delivering value to customers and for managing customer relationships in a way that benefits the organization and its stakeholders." Hayes (2009) state that marketing is simply a tool, that can be used or abused like any other tool. "In essence, marketing is an exchange in which value is offered for value." The consequence of this is: "to initiate the exchange, we must first identify the party with whom we wish to make the exchange. If our focus is on attracting potential students, we have to understand through our marketing research what it is that those potential students are seeking. This almost certainly varies, depending on the type of student we are trying to attract." University marketing should be used to create value for all parties involved and part of marketing should be to identify the target group and research what it is that they need, and how this can be met in a way that also benefits the university. As in the end, for the whole education business to be successful, both the university and the student should benefit from their interactions.

Obviously, one of the most important goals of the marketing, communication and information efforts of a university or university program should be to give insight into that which is offered to potential applicants, in order to help applicant's facing this crucial choice. A critical review on traditional marketing activities of universities in Australia noted that it is important not to remain stuck in the type of marketing promotion that "promises everything to everyone" as this is neither true, nor helpful (Ref). Rather, meaningful differentiation is needed, communicating what is truly distinctive about a program or university. Baldwin and James (2000) also highlight the importance of this.

On the one hand it is therefore important to uncover the core (content) aspects of a program for marketing the program itself, but at the institutional level it is also important to explain how program X given at university A is different from program X given at university B. Are there differences in teaching approach, in the emphasis on theoretical vs. practice, on the vision the university has on the future or on the job market? All of this was hardly addressed in this research. Some items regarding teaching approach were included in the questionnaire, but they didn't make it into factor scales. Probably because there weren't enough items, but perhaps also because it's more difficult to communicate differences in teaching approach to high school students. This is therefore a matter for further research.

Comparison between "Science Education and Communication" and "Higher Education Marketing"

There are some interesting commonalities between the field of Higher Education Marketing and that of Science Education and Communication. As scientific fields they are both relatively new and still developing, while in practice they exist much longer and already rather established. Also, they are both highly interdisciplinary fields. An ongoing debate in the field of Science Communication is whether a science (and technology) communicator should him/herself be a trained scientist (or even engineer). Proponents argue that it is very hard to communicate well about science (and technology) if you do not thoroughly understand the nature of science as well as the specific scientific field you are communicating about. This is hardly possibly if you are not yourself trained in the field, they argue. Opponents say that for a trained scientist it is extremely difficult to make the step back to the lay audience; to have a feeling for what they will not understand and be enables to give a good translation of the scientific knowledge in terms and concepts and contexts they understand. The question here is: what or who is a good science communicator? And connected to this: what are the necessary competencies connected to the (various) professions in science communication? If the necessary competencies are known, the question could become: how can these competencies best be obtained and what type of educational background is required? This could then help answer the question of whether it is a necessity or a handicap to have a scientific background as a science communicator. If the competencies necessary cannot be incorporated in one person, the question becomes: what makes up a good team of science communicators? Which competencies[21] should be in the team? Which educational backgrounds should be in the team?

From the little bit I have read, there seems to be a similar debate going on in the field of higher education marketing. What does a good higher education marketing professional look like? The people working at the marketing department of a university are often either trained communicators with an interest for higher education communication, or trained academicians with an interest for marketing and communication. Hayes (2009) complain that there are seldom people with true marketing backgrounds

[21] Competencies can be defined in various ways. I like the definition used by Spencer and Spencer (1993) that defines competencies to exist in four dimensions: that of knowledge, skills, personality traits and motivations.

working in these departments, with the consequence that marketing principles are not always well integrated throughout the university and that there is a lack of strategic marketing (Hayes, 2009). On the other hand, Hayes also complains that traditional marketing education is primarily aimed at product marketing, not at service marketing, while service marketing is a completely different ballgame. So even if someone has taken a course in marketing, chances are that they still know nothing about service marketing and hardly have a notion of the huge differences that exist between product marketing and service marketing. Even people formally trained in marketing usually learned little to nothing about service marketing or even about or the differences between product and service marketing. So the question comes up: who should be in the marketing department of a university, or what would be a good composition of such a team? Considering the vast differences between the fields that come together in this interdisciplinary field, this is not an easy question. There is a huge difference between an engineering science studies on the one hand, and marketing and communication studies on the other hand. Which competencies are necessary to properly function at the intersection of these fields? And should they all be incorporated in one person, or spread out over the members of a team? As this is an ongoing debate in both fields, perhaps both debates would benefit from a comparison between these debates.

6.4 Reflection on ethics

Is it 'ethical' to try and repel 'risky' students from the Nanobiology bachelor's program? The word 'repel' that is used indeed sounds rather unfriendly and perhaps even unethical, but in reality it means that the aspects that are core to the program but not attractive to students that already have a low chance of succeeding, are emphasized. This is done in order to help the student make a solid choice, better aware of what he/she is getting him or herself into. The 'risky' student that nevertheless still wants to enroll is probably also the segment within the risky cluster that has a better chance of succeeding. Grades are no guarantee for success or dropout, value-related constructs and motivation can also play strong roles as was mentioned in the theory. The 'risky' student that is motivated enough to enroll in the program despite the emphasis on the "Exact" theme probably has thought about it better and has reasons for enrolling that will help him/her to actually make it through. This type of student should off course be welcomed just as much as the dream student. Moreover, a 'risky' student that has thought through his/her choice and who has a high motivation for enrolment in the program could be a more valuable student than the dream student who is more naturally attracted to the program, gave it less serious and is less motivated.

6.5 Relation to the field of Science Communication

The 'building blocks' of the Science communication field.

Recruiting 'fitting' students for the bachelor program Nanobiology has some possible generalizations to recruiting students to study Science Communication, in this way influencing the future professional make-up of the field. Interesting questions here are: "*what are the interesting constructs to use in segmenting the population of potential enrollers with regard to Science Communication?"* And also, *"what are the dimensions of the master's program Science Education and Communication at the Delft University of Technology?"* An even more interesting question for the whole field however is: "*what are the dimensions of the field of Science Communication? How can the essence of this field be described?*" Would it be helpful to describe it in terms of core conceptual content, other distinctive aspects such as the inherent interdisciplinarity of the field, and associated career types? In recent conference proceedings Van der Meij, Hong and Wehrmann (2012) reflect on the value of also adding competencies to this list of possible types of building blocks. The question is essentially, how can one get a hold of the essence of a field that is strongly interdisciplinary and very new, in order to understand and explain it. It turns out that this is very hard and so far there is no consensus in the field of Science Communication regarding an essential definition (Van der Auweraert, 2007). To get a hold of the essential (types of) building blocks for the Nanobiology bachelor in this research, the goal and the target group was first determined. Based on this, the relevant (types of) building blocks were established. The most relevant type of building blocks in this specific case turned out to be the core content elements defining the program and the career perspectives. Perhaps, instead of setting out on a quest to determine "the ultimate building blocks for capturing the essence of the field of Science Communication in its totality", different (types of) building blocks should be used in different cases, each time determined by the communication goal and the target group. I will illustrate this idea using two cases. The communication goal in the first case could for example be to raise awareness of the existence of a Science Communication masters' program and the target group could be Engineering bachelor students in the Netherlands. The communication goal in the second case could be to encourage (certain segments of) the public to engage in Science and Technology throughout the whole 'Science and Technology chain' consisting of government, industry, knowledge institutes, 'the public', educational institutes, etc. (Van der Sanden, 200?; Van Leeuwen 2012). This could help (certain segments of) 'the public' to get a better understanding of the nature of Science and Technology - the bigger purpose of this on its turn being science and technology literacy of the public and all the general goals of the field, such as democracy. Different types of building blocks might be required in order to explain Science Communication in these two different cases.

Another important lesson from this research is that the way the building blocks are defined and organized can be very different in the minds of the target group than in the minds of their designers. Defining the building blocks should therefore also be done together with the target group. In the case of Science Communication this strategy could perhaps even help to discover new insights on the essence of Science Communication. Defining the building blocks of a Science Communication masters' program in collaboration with the target group of engineering bachelor students, could inspire a whole new perspective on how the field should be defined. Similarly, defining the building blocks of science communication in collaboration with (certain segments) of the public and in relation with the whole "Science and Technology chain" could inspire new approaches towards capturing the field. I can imagine that for example "values" (meaning norms and ethical values), could arise as an important type of building block from this second case. We saw in the model of Eccles et al., (2002) that expectancy- as well as value-related constructs influence academic choice and success. (Note that the term 'value' used in this model has a broader meaning than the term value that I am referring to). Various "subjective task values" are mentioned in the model. The one termed 'attainment value' is in particular interesting as it contains notions of personal norms and values. Most science communication efforts of today focus on the subjective task value 'interest enjoyment', (see the model), and try to influence public opinion through 'education' of 'the public'. 'The public' is encouraged to expose itself to this education for reasons of 'interest enjoyment'. Usually the focus is then on entertaining people based on their assumed curiosity of natural or technological phenomena. There is nothing wrong with this approach off course, but it is rather limited. It is limited both in its depiction of the nature of Science and Technology, as well as in its assumptions regarding 'the public'. Not everybody enjoys it to better understand natural or technological phenomena. Trying to convince the entire 'general public' to cultivate such an interest, might be an approach that misses the more fundamental reasons for 'the public' to disengage from Science and Technology development. I think it would be very interesting to focus more on the other value- and expectancy-related constructs in defining strategies for science communication. In particular, attainment value and norms and values that might be underlying reasons for segments of the public to disengage from certain types of science and technology. This could be very relevant for emerging and potentially controversial fields such as Nanotechnology and Nanobiology. A very relevant type of building block for these fields in relation to certain target groups could be value related building blocks. Recent research (Koppeschaar et al., 200) revealed that the Dutch population can be segmented in terms of their expectations of the future impact of Nanotechnology and whether or not this impact will be positive. Four segments were identified in this way: optimists (big consequences, positive), ambivalents (consequences could be big or small, positive or negative), skeptics (no big consequences, could be positive or negative) and critics (big consequences, negative). The optimist type might be naturally inclined to engage in Nanotechnology in a certain way, while the critic might avoid engagement. Understanding the values of various segments of the public with regard to certain types of science and technology seems necessary for development of science communication strategies, especially with regard to the more controversial areas of science and technology. Summarizing from Scheufele et al. (2009): "citizens rely on cognitive shortcuts or heuristics to make sense of issues for which they have low levels of knowledge such as Nanotechnology (Scheufele, 2006). These heuristics can include predispositional factors, such as ideological beliefs or value system (Kahan et al., 2008)". Their research (Scheufele et al., 2009) indicates a direct correlation between 'likeliness to agree that nanotechnology is morally acceptable' and level of religiosity. And I think religious views are strongly correlated to value-systems. To ignore the connection between values and perspectives on (emerging) science and technology could result in unhelpful or very limited science communication strategies.

Dropout of higher education versus disengagement from Science and Technology.

In the above paragraph I involved the Eccles' model in reflecting on the field of Science Communication. Tinto's dropout model also offers an interesting framework for reflection. Tinto focused on academic dropout, but perhaps this model can also be used in reflecting on why people (dis)engage with (or drop out of) Science and Technology; early or later in life, with respect to certain parts of the "chain"; or with respect to certain areas of Science and Technology. Looking at his model (see Figure 3.10 in chapter 3) I think all of the boxes from the Tinto (1975) dropout model could be connected to people's science and technology engagement behavior. Surely family background, individual attributes and schooling have an influence on whether people develop some sort of commitment towards science and technology engagement. The academic system could be translated to the Science and Technology 'chain' (Van der Sanden), covering all parties somehow involved in Science and Technology (from knowledge institutes to industry). Throughout this chain things can happen that encourages people to further engage with Science and Technology, or to "drop out" of it. The box 'Grade performance' could for example be related to (professional) performance somewhere in the chain. The box "Intellectual Development" could be translated to science and technology literacy development or. (Professional) performance within the chain and science and technology literacy development could then lead to better integration and engagement with science and technology, similar to the "Academic Integration" in the model. Science and Technology (dis)engagement could also be related to the bottom side of the model. Peer-group interactions could be directly copied from the model. For example: if you like the people you meet at science festivals or if people in your personal network go to science festivals, chances are higher that you will also go to science festivals. The box "Faculty Interactions" could be translated to experiences with important people within the Science and Technology chain. These could be scientists you meet at an open day of a university, but also an industry CEO or the minister of science education and culture that you see on television. Can an individual can identify with these people? Peer group interactions and interactions with people somehow identified with Science and Technology will influence an individual's 'social integration' into the Science and Technology chain. Tinto also mentions values in connection with both academic and social integration. If an individual's values are not compatible with values of his or her academic peer group, faculty staff, or with values inherent to academia, this will encourage dropout. Considering what was said in the previous paragraph and the indication from the work of Scheule et. al. (2009), it becomes an interesting question whether there are fundamental clashes of values between certain segments of society and certain parts or aspects of the Science and Technology chain? If so, this could contributes towards disengagement from these segments of society. Also, are there clashes of values between certain Science and Technology icons (individuals strongly connected to a certain part of the Science and Technology chain) and individuals in society? If an individual feels strongly alienated by things that the minister of science, education and culture or the CEO of Philips or the head of the KNAW says or does for example, this could encourage disengagement from parts of the science and technology chain. But also, if someone had a very uninspiring physics teacher, this could have effects resulting in disengagement from Science and Technology on the short or the long run. Uncovering and mapping the values inherent to certain segments of the Science and Technology chain and the individuals representing it and comparing this to value systems of certain segments of society could therefore be very valuable in understanding disengagement of Science and Technology as well as development of Science Communication strategies that take the role of values into account.

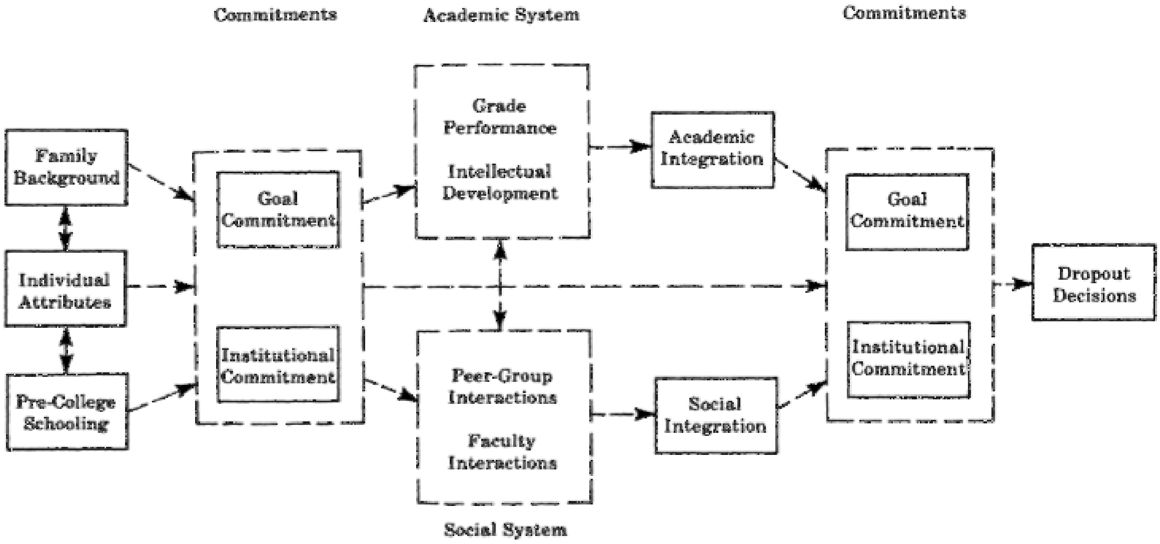

Figure 6.1: Tinto's originally proposed model (repeat from Figure 3.10): Dropout from College (Tinto 1975)

Necessity of Segmentation in Science Communication

Segmentation is a key issue in mass communication. In science communication in particular, there is often this reference to 'the general public'. But in reality there is no such thing as 'the general public' or a 'general target group'. There is always a goal with communication, that is generally related to an action you want to move your target group towards. Depending on that goal, there will be key attributes by which you can define and segment your target group.

To illustrate this idea: in the case of this research, the (communication) goal is to encourage students that will fit the Nanobiology program to enroll and to discourage students that would not fit the program to *not* enroll. The key attributes of my target group therefore are: interest to enroll in the Nanobiology program, and chances of success in the program. These attributes are at a rather abstract level and therefore have to be operationalized into indicators that are available at the more practical level. A level of theory and perhaps also empirical research is needed for this operationalization. Based on these key attributes the target group is segmented.

The interesting thing now is that because a communication message is always interpreted to some degree, there will automatically be segmentation with regard to how a message is understood, and this will on its turn have an influence on the actions that the receivers of the message are inspired towards. If the target audience is not intentionally segmented and a communication message designed in accordance with the goals for and attributes of the various segments - but instead a general message is sent out, intended for 'everyone' - it is not possible to control the way in which this segmentation happens. Consequently it will be hard to predict the effect the message has this in terms of actions taken by its recipients and whether or not this is according to the original communication goal. Simply designing a message intended for 'the general public', with an accompanying goal for 'the general public', could therefore have unwanted and unforeseen side effects.

The challenge now is to control the segmentation caused by your message. To control which group understands which message. So the segmentation happens anyway, always. The art is to understand how and why that segmentation happens, and if you can control it.

Honest versus strategic communication?

The terms 'strategic communication' and 'honest communication' were used a few times in this thesis. At a first glance they could be interpreted to mean two opposite things. Personally I don't think this is necessary. Strategic communication in my mind simply means communication with a well defined goal, in line with the (strategic) goals of an institution (or organization), together with a plan designed to reach this goal and to evaluate whether the communication goal has been reached. This includes the use of a communication message that is designed according to the communication goal; and for this design using proper knowledge to make a reliable operationalization from the communication goal to the communication message, drawing upon lessons learned from science or practice. Like communication and marketing, strategic communication is simply a tool; and like any tool, it can be used an abused. Strategic communication is connected to the goals of its commissioning institution, and uses a well designed communication plan, imbedded in the institutional organization, to contribute towards reaching this goal through communication. (In this way it does become a more complicated tool, and when tools become more complicated, abuse can can become harder to detect.)

To me the question is not whether strategic communication can be honest communication, but: when does strategic communication become dishonest communication? In my opinion this is related to the connection there is between the communication goal and the communication message. When these two become alienated from each other, strategic communication becomes dishonest communication. For example, when the communication goal is: "encourage as many people as possible to buy a certain product, irrespective of their circumstances or any of their personal attributes" while the communication message is: "if you, as a unique and special person whom we value, buy this product, all your problems will be solved" I think it is hard to defend the relationship between these two. I think it doesn't matter whether this concerns a service or a product.

7 Recommendations

7.1 Practical recommendations to the commissioner

Based on this research and the main conclusions I would recommend Marketing, Communication and Information team of the Nanobiology bachelor's program the following:

1) Emphasize the exact nature of Nanobiology in all information efforts: presentations, brochures, the website, etc. This research indicates that it would help attract students that fit the program in terms of overall interest as well as success likelihood. Emphasizing the exact nature of this program will also help differentiate it from another interdisciplinary program offered at TNW: Life Sciences. The Nanobiology program can mistakenly be seen as rather similar to Life Science, while there are stark and essential differences between these two programs, in particular when comparing their exact nature. The focus on physics and mathematics is much stronger in the Nanobiology program than in the Life Science program. Students that have a strong interest in biology and chemistry but are repelled by a strong emphasis on physics and mathematics would most probably be much happier in the Life Sciences program than in the Nanobiology program. It is therefore extra important to help students that feel attracted to both programs, perhaps because they don't immediately see the strong difference in emphasis on physics and mathematics between the programs, to pick the study in which they fit best. There are students who make study choices without informing themselves very well, and there is a danger that they choose Nanobiology because they're not sure what they want yet. I think an interdisciplinary program with an exciting name such as Nanobiology is more interesting to this type of student than an obviously heavy study with a strong disciplinary (and therefore 'option limiting') focus such as mathematics. The idea of combining biology and chemistry with physics and mathematics might create the illusion that by choosing this study you still keep all your options open and you don't need to know what you want because it is nice and mixed, in contrast to a more established and more disciplinary program. In reality the Nanobiology program is more specialized than most disciplinary programs and has as its main purpose to educate scientists for this new field. Students who therefore choose this program because they don't know what they want yet could be in for surprise and a disappointment. Because this type of students is also more likely to not inform him/herself very well, it is important that the exact nature of the study is very easy to recognize from any piece of information.

2) Do not put a strong emphasis on the "alpha direction" careers. I would even suggest to leaving them out fully. This type of career is not distinctive to this program at all, and it doesn't attract the target population. It also doesn't help to eliminate the possible illusion the interdisciplinary and novelty of the program could create: that it is broad and generalist and therefore suitable for someone who doesn't yet know what he/she wants.

3) Start informing high school students about the program before they have made a choice for a higher education program. From the (430 valid) 5VWO respondents who completed the questionnaire only 26% indicated that they have not yet made a decision regarding higher education at all (see Appendix 22). Of the remaining 74%, 43% answer that they have decided a little bit and 31% already made a rather specific decision. The students that have already made a choice, will not easily change this choice (ref J.J. Knoop). And the students that haven't made a choice yet, have a higher chance of dropout. The earlier a student makes a higher education decision, the better his/her chances to persist (Warps et al., 2010).

Furthermore, considering the requirement that students need a double profile to be eligible for enrolment, it would be helpful for them to know this while they can still make decisions regarding their profile.

4) Based on the discussion I would suggest that there should be some attention for students value development with regard to this new field: perhaps as part of the philosophy of science course and/or the introduction to Nanobiology. When students enter the program their value related attitudes towards Nanobiology are probably not that well developed yet as there is little attention for this in high school. During their studies however students sense of values will be developing and their values with regard to Nanobiology could influence their achievements regarding the program and their later career choices. This recommendation is not based on the main results from this research however, it is a more speculative recommendation.

7.2 Recommendations for further research

Based on this research and the analysis outcome I recommend further research into what the more difficult concepts connected to this program mean to high school students. This is important as some of these concepts truly differentiate the program from other programs, and could fit some students better than others. It is possibly not clear to high school students what is meant by: "interdisciplinary" and by the concepts in the "unfamiliar" scale: "technical", "engineering organisms", "nanoscience", "laboratory work" and "nanotechnology applied to biology". If concepts are used without knowing how they are understood by high school students, this could lead to miscommunication. To illustrate this idea, I noted that a picture of a girl in a lab coat looking at something through a microscope was used on the first pieces of information about the Nanobiology program. From what I picked up informally during this research, I think this might not be the best way to communicate the essence of this program or to attract the 'right' students. "Microscopes" was one of the items on the preliminary questionnaire completed by the visitors of the information afternoons and this was the lowest scoring item: of the 24 respondents only 18 (75%) felt it really belonged to this study; 3 of them (12,5%) felt microscopes are unattractive and 9 (37,5%) of felt they were attractive. The sample of respondents is very small of course but considering that most of these high school students were interested and excited enough to make the effort to come to the Nanobiology information day, it is at least interesting that this item scored lowest. While taking the final questionnaires with the 5VWO students one of my test persons (who completed the questionnaire out loud) noted that she really dislikes microscopes, because it reminds her of endlessly having to draw uninteresting objects that they were forced to do in biology lessons. The association that high school students have with a microscope and consequently the concept 'microscope' in their minds, is perhaps completely different from what it is intended to represent in Nanobiology. I think Nanobiology distinguishes itself with regard the concept of a microscope by, other than Life Sciences or Biology, emphasizing the importance of understanding how a microscope works. This in order to enable proper interpretation of the data collected by specialized microscopes and perhaps even improvement of its functioning. It is also used in the lab as a simple observation instrument, but this represents a very small part of Nanobiology and in my opinion not the core or distinguishing content of the program. This notion is probably not communicated at all by showing a picture of someone looking into a microscope. There are probably many more of such concepts that I suspect have a completely different meaning in the minds of high school students than what they have in the theory and practice of Nanobiology, and this could lead to a misrepresentation of the program. A first attempt at this uncovering what Nanobiology concepts mean in the minds of high school students was done with this research, using factor analysis to group the concepts. Also, the open question regarding associations with and feelings about Nanobiology (data not included in this report) is a small first attempt to get a grip on how students understand concepts core to this program. I think further research is however necessary.

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Appendices

Appendix 1 Elaboration explorative literature search “higher education choice”

An exploratory literature search into student choice processes with regard to higher education was conducted using search engines web of science, Google scholar and Google. Initial search keywords were:

Web of Knowledge (Topic search):

- choice AND student AND education; no relevant articles but produced new keywords ‘college choice process’

- high school AND student AND college AND choice AND processes; no relevant articles

Google search:

- “college choice processes of high school students” gave a beautiful document (Kinzie Hossler 2004) about the history of college choice in America with an abundance of interesting references. The practical value was limited however as its focus was America and choice processes of students choosing an institution rather than a program. I realized that I would need to change my search strategy to find information specific to Holland and to choosing a program instead of an institution.

Google scholar:

- “Choosing tertiary education in Holland” produced Dekker (2009) and (1996) which seemed interesting but was not freely accessible. Dekker (2009) focused on the determinants influencing subject choice of pupils in secondary education having to choose their school subjects. This is interesting but subject choice in high school is different from choosing a university program. As it was not free I did not try to obtain it. Similar for Dekker (1996). The abstract from Dekker (2009) did produce new search terms: ‘determinants’ and ‘subject choices’.

Web of Knowledge (Topic search):

- “University AND program AND choice AND process AND/OR determinant AND high school AND STEM OR physics OR biology” gave very few interesting articles, just three that are vaguely related (see END note). Most articles were about medicine and medical students, while I wanted articles about STEM, physics and molecular biology and nanoscience. I refined “university AND choice AND high school” with the terms “nanotechnology” OR “nanoscience”. This also didn’t give results.

The keywords search in Web of Knowledge didn’t produce enough practical results so I tried a wildcard: hoping to find more specific and practical information I simply typed in my question in Dutch into Google:

Google:

- “Wat vinden middelbare scholieren belangrijk bij het kiezen van een vervolgopleiding? Welke factoren spelen een rol?”

This lead to a host of practical, valuable, specific information, mostly through the references found in the grey literature that came out of the Google search. The master thesis of Habema Broekema led to Lange. & Vierke (2009) which lead to the most important documents: Langen (2010), Broek et al. (2009), Beta Mentality (Beta Mentality, 2010).

Google scholar:

- “Model keuzeproces vervolgopleiding middelbare scholieren” gave Haar 2009 and Verboon 2008, leading to more interesting references.

- “Model keuzeproces **beta** vervolgopleiding middelbare scholieren” gave a very valuable thesis by (Knoop, 2008),

- Via more reference from documents resulting from these searches, I find “Gelderblom, Koning Hartog” which leads to: Biermans 2003 and another interesting documents that was however not freely available unfortunately (Berkhoud, E.E., en M.J. van Leeuwen 2000).

Appendix 2 Elaboration explorative literature search "Higher Education Marketing"

Appendix table 1: Web of Knowledge (All Topic Search)

Keywords used	Main articles/documents found
Netherlands AND higher AND education AND marketing AND choice AND consumer	None
Netherlands AND higher AND education AND marketing AND choice	None
Netherlands AND higher AND education AND choice AND consumer	None
Netherlands AND higher AND education AND choice AND higschool	None
Netherlands AND higher AND education AND high AND school AND choice	27 results. Possibly interesting: - Explaining Participation Differentials in Dutch Higher Education: The Impact of Subjective Success Probabilities on Level Choice and Field Choice Author(s): Tolsma, J (Tolsma, Jochem)[1]; Need, A (Need, Ariana)[1]; de Jong, U (de Jong, Uulkje)[2] - Title: Determinants of the regional demand for higher education in the Netherlands: A gravity model approach - Author(s): Sa C; Florax RJGM; Rietveld P - Title: School finance and school choice in the Netherlands Author(s): Ritzen JMM; van Dommelen J; de Vijlder F However in the end not relevant enough
Netherlands AND higher AND education AND model AND choice AND processes	None
Netherlands AND higher AND education AND model AND choice AND process	None
Netherlands AND higher AND education AND marketing AND choice AND process	None

Keywords used	Main articles/documents found
Netherlands AND higher AND education AND marketing	Perhaps interesting: Title: Job search and academic achievement Author(s): van der Klaauw Bas; van Vuuren Aico Source: EUROPEAN ECONOMIC REVIEW Volume: 54 Issue: 2 Pages: 294-316 DOI: 10.1016/j.euroecorev.2009.07.001 Published : FEB 2010 Title: The demand for higher education in The Netherlands, 1950-1999 Author(s): Canton E; de Jong F Source: ECONOMICS OF EDUCATION REVIEW Volume: 24 Issue: 6 Pages: 651-663 DOI: 10.1016/j.econedurev.2004.09.006 Published : DEC 2005 Title: RAPID EXPANSION AND EXTENSIVE DEREGULATION: THE DEVELOPMENT OF MARKETS FOR HIGHER EDUCATION IN THE NETHERLANDS Author(s): Salerno Carlo Editor(s): Teixeira P; Jongbloed B; Dill D; et al. Conference: 3rd Douro Seminar on Markets in Higher Education - Mature Economies Location: Pinhao, PORTUGAL Date: OCT 01-03, 2003 Sponsor(s): CIPES; HEDDA Source: MARKETS IN HIGHER EDUCATION: RHETORIC OR REALITY? Book Series: Higher Education Dynamics Volume: 6 Pages: 271-290 Published: 2004 Times Cited: 1 (from All Databases) Title: Educating competent professionals for the horticultural job market; Analysis of the

	new model for higher education in the Netherlands Author(s): Trip G; Maijers W; Lossonczy T Editor(s): Bokelmann W Conference: 15th International Symposium on Horticultural Economics and Management Location: Berlin, GERMANY Date: AUG 29-SEP 03, 2004 Sponsor(s): Deutsch Forsch Gemeinsch; Poppelmann Teku; Gartenbauzentrale Papenburg; Gartenbau Versicher; GEFOMA GmbH Source: PROCEEDINGS OF THE XVTH INTERNATIONAL SYMPOSIUM ON HORTICULTURAL ECONOMICS AND MANAGEMENT Book Series: ACTA HORTICULTURAE Issue: 655 Pages: 451-460 Published: 2004 Times Cited: 0 (from All Databases) Title: Fields of study, acquired skills and the wage benefit from a matching job Author(s): van de Werfhorst HG Source: ACTA SOCIOLOGICA Volume: 45 Issue: 4 Pages: 287-303 Published: 2002 Times Cited: 9 (from All Databases) Most articles are about the effect of social background on higher education choices/tracks… Which is not what I want.
Netherlands AND higher AND education AND decision AND making	None. Most articles are about euthanasia and birth control

Appendix 3   Validation literature search Web of Knowledge

Appendix table 2: Web of Knowledge search: Study choice factors, refined with 'science' and 'medical'

#30	Author=(Eccles) AND Topic=(academic) Refined by: Topic=(model) *DocType=All document types; Language=All languages;*
#29	Author=(Eccles) AND Topic=(academic) Refined by: Topic=(predict) *DocType=All document types; Language=All languages;*
#28	Author=(Eccles) AND Topic=(academic) *DocType=All document types; Language=All languages;*
#27	Author=(Eccles) AND Topic=(academic) AND Topic=(student) Refined by: Topic=(factors) *DocType=All document types; Language=All languages;*
#26	Author=(Eccles) AND Topic=(academic) AND Topic=(student) Refined by: Topic=(choice) *DocType=All document types; Language=All languages;*
#25	Author=(Eccles) AND Topic=(academic) AND Topic=(student) *DocType=All document types; Language=All languages;*
#24	Author=(Eccles) AND Topic=(academic) AND Topic=(student) *DocType=All document types; Language=All languages;*
#23	Author=(Eccles) AND Topic=(academic) AND Topic=(student) AND Topic=(program) AND Topic=(factor) *DocType=All document types; Language=All languages;*
#22	Author=(Eccles) AND Topic=(academic) AND Topic=(student) AND Topic=(enrollment) AND Topic=(factor) AND Topic=(program) *DocType=All document types; Language=All languages;*
#21	Author=(Eccles J) AND Topic=(academic) AND Topic=(student) AND Topic=(enrollment) AND Topic=(factor) AND Topic=(program) *DocType=All document types; Language=All languages;*
#20	Author=(Eccles JS) AND Topic=(academic) AND Topic=(student) AND Topic=(enrollment) AND Topic=(factor) AND Topic=(program) *DocType=All document types; Language=All languages;*
#19	Author=(influence) AND Topic=(academic) AND Topic=(student) AND Topic=(enrollment) AND Topic=(factor) AND Topic=(program) *DocType=All document types; Language=All languages;*
#18	Topic=(influence) AND Topic=(choice) AND Topic=(student) AND Topic=(enrollment) AND Topic=(factor) AND Topic=(program) *DocType=All document types; Language=All languages;*
#17	Topic=(influence) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) AND Topic=(program) AND Topic=(factor) Refined by: Topic=(science) *DocType=All document types; Language=All languages;*
#16	Topic=(influence) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) AND Topic=(program) AND Topic=(factor) Refined by: Topic=(Biomedical) *DocType=All document types; Language=All languages;*
#15	Topic=(influence) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) AND Topic=(program) AND Topic=(factor) Refined by: Topic=(Engineering) *DocType=All document types; Language=All languages;*
#14	Topic=(influence) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) AND Topic=(program) AND Topic=(factor) Refined by: Topic=(STEM) *DocType=All document types; Language=All languages;*
#13	Topic=(influence) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) AND Topic=(program) AND Topic=(factor) *DocType=All document types; Language=All languages;*

#12	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) AND Topic=(bachelor) *DocType=All document types; Language=All languages;*
#11	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) AND Topic=(Bsc) *DocType=All document types; Language=All languages;*
#10	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) AND Topic=(program) *DocType=All document types; Language=All languages;*
#9	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) AND Topic=(Bachelor) AND Topic=(program) *DocType=All document types; Language=All languages;*
#8	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) Refined by: Topic=(medical) AND Topic=(high school) AND Topic=(program) *DocType=All document types; Language=All languages;*
#7	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) Refined by: Topic=(medical) AND Topic=(high school) AND Topic=(bio) *DocType=All document types; Language=All languages;*
#6	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) Refined by: Topic=(medical) AND Topic=(high school) *DocType=All document types; Language=All languages;*
#5	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) Refined by: Topic=(medical) AND Topic=(high school) *DocType=All document types; Language=All languages;*
#4	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) Refined by: Topic=(medical) *DocType=All document types; Language=All languages;*
#3	Topic=(predict) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) *DocType=All document types; Language=All languages;*
#2	Topic=(program) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) Refined by: Topic=(Netherlands) *DocType=All document types; Language=All languages;*
#1	Topic=(program) AND Topic=(choice) AND Topic=(student) AND Topic=(higher) AND Topic=(education) *DocType=All document types; Language=All languages;*

Appendix table 3: STEM specific: choice and success factors

#12	Topic=(STEM) AND Topic=(factors) AND Topic=(choice) AND Topic=(career) AND Topic=(high) AND Topic=(school) *DocType=All document types; Language=All languages;*
#11	Topic=(STEM) AND Topic=(factors) AND Topic=(choice) AND Topic=(career) *DocType=All document types; Language=All languages;*
#10	Topic=(STEM) AND Topic=(factors) AND Topic=(choice) AND Topic=(education) *DocType=All document types; Language=All languages;*
#9	Topic=(STEM) AND Topic=(factors) AND Topic=(choice) AND Topic=(education) AND Topic=(pathway) *DocType=All document types; Language=All languages;*
#8	Topic=(STEM) AND Topic=(student) AND Topic=(persistence) AND Topic=(indicators) *DocType=All document types; Language=All languages;*
#7	Topic=(STEM) AND Topic=(student) AND Topic=(persistence) AND Topic=(indicators) *DocType=All document types; Language=All languages;*
#6	Topic=(STEM) AND Topic=(student) AND Topic=(success) AND Topic=(indicators) *DocType=All document types; Language=All languages;*
#5	Topic=(STEM) AND Topic=(success) AND Topic=(student) *DocType=All document types; Language=All languages;*
#4	Topic=(STEM) AND Topic=(success) AND Topic=(student) AND Topic=(factors) *DocType=All document types; Language=All languages;*
#3	Topic=(STEM) AND Topic=(success) AND Topic=(student) AND Topic=(factors) AND Topic=(high school) *DocType=All document types; Language=All languages;*

#2	Topic=(STEM) AND Topic=(science) AND Topic=(student) AND Topic=(attrition) AND Topic=(factors) *DocType=All document types; Language=All languages;*
#1	Topic=(STEM) AND Topic=(science) AND Topic=(student) AND Topic=(attrition) *DocType=All document types; Language=All languages;*

Appendix table 4: Web of Knowledge search: study success factors

#21	Topic=(Factors) AND Topic=(Influencing) AND Topic=(Engineering) AND Topic=(students) AND Topic=(graduation) *DocType=All document types; Language=All languages;*
#20	Topic=(RIASEC) AND Topic=(Choice) AND Topic=(Interest) AND Topic=(program) *DocType=All document types; Language=All languages;*
#19	Topic=(RIASEC) AND Topic=(Choice) AND Topic=(Interest) AND Topic=(program) AND Topic=(high) AND Topic=(school) *DocType=All document types; Language=All languages;*
#18	Title=("Do Interests and Cognitive Abilities Help Explain College Major Choice Equally Well for Women and Men?") *DocType=All document types; Language=All languages;*
#17	Title=(Do Interests and Cognitive Abilities Help Explain College Major Choice Equally Well for Women and Men?) *DocType=All document types; Language=All languages;*
#16	Topic=(Do Interests and Cognitive Abilities Help Explain College Major Choice Equally Well for Women and Men?) *DocType=All document types; Language=All languages;*
#15	Topic=(Do Interests and Cognitive Abilities Help Explain College Major Choice Equally Well) *DocType=All document types; Language=All languages;*
#14	Title=(Do Interests and Cognitive Abilities Help Explain College) *DocType=All document types; Language=All languages;*
#13	Topic=(STEM) AND Topic=(factors) AND Topic=(choice) AND Topic=(career) AND Topic=(high) AND Topic=(school) *DocType=All document types; Language=All languages;*
#12	Topic=(STEM) AND Topic=(factors) AND Topic=(choice) AND Topic=(career) AND Topic=(high) AND Topic=(school) *DocType=All document types; Language=All languages;*
#11	Topic=(STEM) AND Topic=(factors) AND Topic=(choice) AND Topic=(career) *DocType=All document types; Language=All languages;*
#10	Topic=(STEM) AND Topic=(factors) AND Topic=(choice) AND Topic=(education) *DocType=All document types; Language=All languages;*
#9	Topic=(STEM) AND Topic=(factors) AND Topic=(choice) AND Topic=(education) AND Topic=(pathway) *DocType=All document types; Language=All languages;*
#8	Topic=(STEM) AND Topic=(student) AND Topic=(persistence) AND Topic=(indicators) *DocType=All document types; Language=All languages;*
#7	Topic=(STEM) AND Topic=(student) AND Topic=(persistence) AND Topic=(indicators) *DocType=All document types; Language=All languages;*
#6	Topic=(STEM) AND Topic=(student) AND Topic=(success) AND Topic=(indicators) *DocType=All document types; Language=All languages;*
#5	Topic=(STEM) AND Topic=(success) AND Topic=(student) *DocType=All document types; Language=All languages;*
#4	Topic=(STEM) AND Topic=(success) AND Topic=(student) AND Topic=(factors) *DocType=All document types; Language=All languages;*
#3	Topic=(STEM) AND Topic=(success) AND Topic=(student) AND Topic=(factors) AND Topic=(high school) *DocType=All document types; Language=All languages;*
#2	Topic=(STEM) AND Topic=(science) AND Topic=(student) AND Topic=(attrition) AND Topic=(factors) *DocType=All document types; Language=All languages;*
#1	Topic=(STEM) AND Topic=(science) AND Topic=(student) AND Topic=(attrition) *DocType=All document types; Language=All languages;*

Appendix 4 List of promotion materials used for qualitative analysis

- Nanobiology Bachelor Promotion flyer 2011
- Nanobiology Bachelor Promotion flyer 2012
- Tu Delft Bachelor gids 2011, section on Nanobiology (page 100-101)
- Informatiedossier Toets nieuwe opleiding Nanobiologie. Oktober 2011. Delft Rotterdam (Chapter 2, page 33 of Appendix A, Appendix B)
- Internal promotion document (Bsc in Nanobiology Introduction, March 20, 2011 “A new Scientific field, A new Educational Program: Nanobiology BSc”)
- Transcript of elevator pitches in the collegerama video made of the information meeting for staff (Date: December 2011)
- Transcript of video of presentation given at the open days (Date: 5 April 2012).
- Powerpoint presentation used during the same open day presentation.

Appendix 5 Preliminary codes used for preliminary information afternoon questionnaires: relation to codes from TNO document

Preliminary list of Nanobiology aspects and connection to codes made from the 'Toets Nieuwe Opleiding' document.

Black bold underlined gives the type (career, content, other)
Red gives the terms used in the preliminary questionnaire
Normal gives the codes from the TNO document. *Italic gives some context*
Light blue means it was used in the final questionnaire but not in the preliminary one

Carriere:

Wetenschapper:

aan een universiteit
aan een medische instelling (ziekenhuis)
in een bedrijf

Promotietraject
Zuivere onderzoeksloopbaan

Laboratorium medewerker

Een linking pin/verbinder:

tussen wetenschap en techniek bedrijven
tussen verschillende wetenschappen

De linking pin tusen de techniek en de wetenschap in een technisch-commercieel bedrijf

Wetenschapsjournalist
Wetenschapsjournalist

Wetenschapsadviseur (bijvoorbeeld bij de overheid)

Docent
Docent (biologie? Natuurkunde? Wiskunde?)

(used in the final questionnaire, not in the preliminary questionnaire)
Technisch-commercieel medewerker bij een bedrijf dat apparatuur levert voor wetenschappelijk onderzoek
(used in the final questionnaire, not in the preliminary questionnaire)
Geavanceerde onderzoeksmethoden (in minor)
Onderzoeksprojecten (minor)

Niet gebruikt (niet relevant genoeg):
Logica en filosofie van wetenschappelijk onderzoek
Masterstudie

Inhoud:
(Moleculaire) Biologie
Gezondheid en ziekte begrijpen op nanoschaal
(Nieuwe) medicijnen
Moleculaire biologie.
Celniveau.

Biologen
Geneeskundigen
Levende cellen
Biomedische vraagstukken
Moleculaire basis van gezondheid en ziekte (begrijpen)
Levende cellen en organismen
Gerelateerd aan
Moleculaire basis van gezondheid en ziekte *Kennen en begrijpen*
Kwantitatief begrip van de biologie *in relatie tot* fundamentele aspecten van menselijke gezondheid en ziekte.

Nanowetenschap
Nanowetenschappen (toegepast op de biologie)

Levende cellen/organismen op nanoschaal bestuderen
Techniek
Levende organismen op nanoschaal op fundamentele wijze te kunnen analyseren, karakteriseren en manipuleren.

Combinatie/Integratie van verschillende vakgebieden
Snijvlak van biologie en natuurkunde
Fysische processen op celniveau.
Fysische processen op celniveau (kunnen duiden)
Kwantitatieve methoden
Wiskundige en natuurkundige principes
Convergentie van biologie en natuurkunde
Interdisciplinair
Geïntegreerde benadering biologie, natuurkunde, (wiskunde, schiekunde).
Nieuwe perspectief "Nanobiologie". Nieuwe perspectief op biologie + natuurkunde.
Geintegreerd aanbod kennis
Belichting onderlingen verbanden tussen onderwerpen
Biologievakken met accent op kwantitatieve aspecten
Toelichting fysische principes in Natuurkunde vakken met voorbeende vanuit de biologie
Brugvakken: ingaan op de verbanden tussen natuurkunde en biologie
Inzicht in overlap wetenschapsgebieden biologie en natuurkunde
Wederzijdse relevantie wetenschapsgebieden biologie en natuurkunde
Snijvlak tussen natuurkunde en biologie

Fundamentele kennis
Fundamenteel karakter
Fundamentele kennis
Fundamentele kennis van wetenschapsgebieden natuurkunde en biologie
Fundamentele kennis van wiskunde
Fundamentele kennis van natuurkunde
Fundamentele kennis van biologie
Fundamentele kennis van winabio kunnen toepassen.
Fundamentele en algemene principes vanuit de biologie en de natuurkunde
In coherentie context worden gepresenteerd
Samenhang fundamenetele en algemene principes vanuit de biologie en de natuurkunde.

Moeilijke studie

Natuurkunde
Scheikunde
Wiskunde
Natuurkunde
Scheikundebrugvakken…
Eindkwalificaties uitgebreid:
- vakinhoudelijk

Wetenschappelijk onderzoek
Wetenschappelijke inzichten
Studenten met belangstelling voor wetenschappelijk onderzoek
Eindkwalificaties:
Samenvatting:
- Kennis en vaardigheden om op academische niveau bij te dragen op de gebieden:
- Biofysica
- Bionanoscience
- Biomedicine
- vraagstukken herkennen, formuleren en oplossen op deze vakgebieden.

Experimenten/Proefjes doen
Met technische apparaten werken
Microscopen
Laboratoriumwerk
Theoretische kennis EN praktische vaardigheden
Basale labvaardigheden, *gericht op* biomedische en biofysische laboratoria.

Programmeren (modellen maken in de computer)

Innovatief (nieuw)
Nieuw ontwikkelde vakken, specifiek voor dit curriculum.
Thematische en methodische verbanden tussen de verschillende vakken tot hun recht laten komen.

Engels
Internationale orientatie

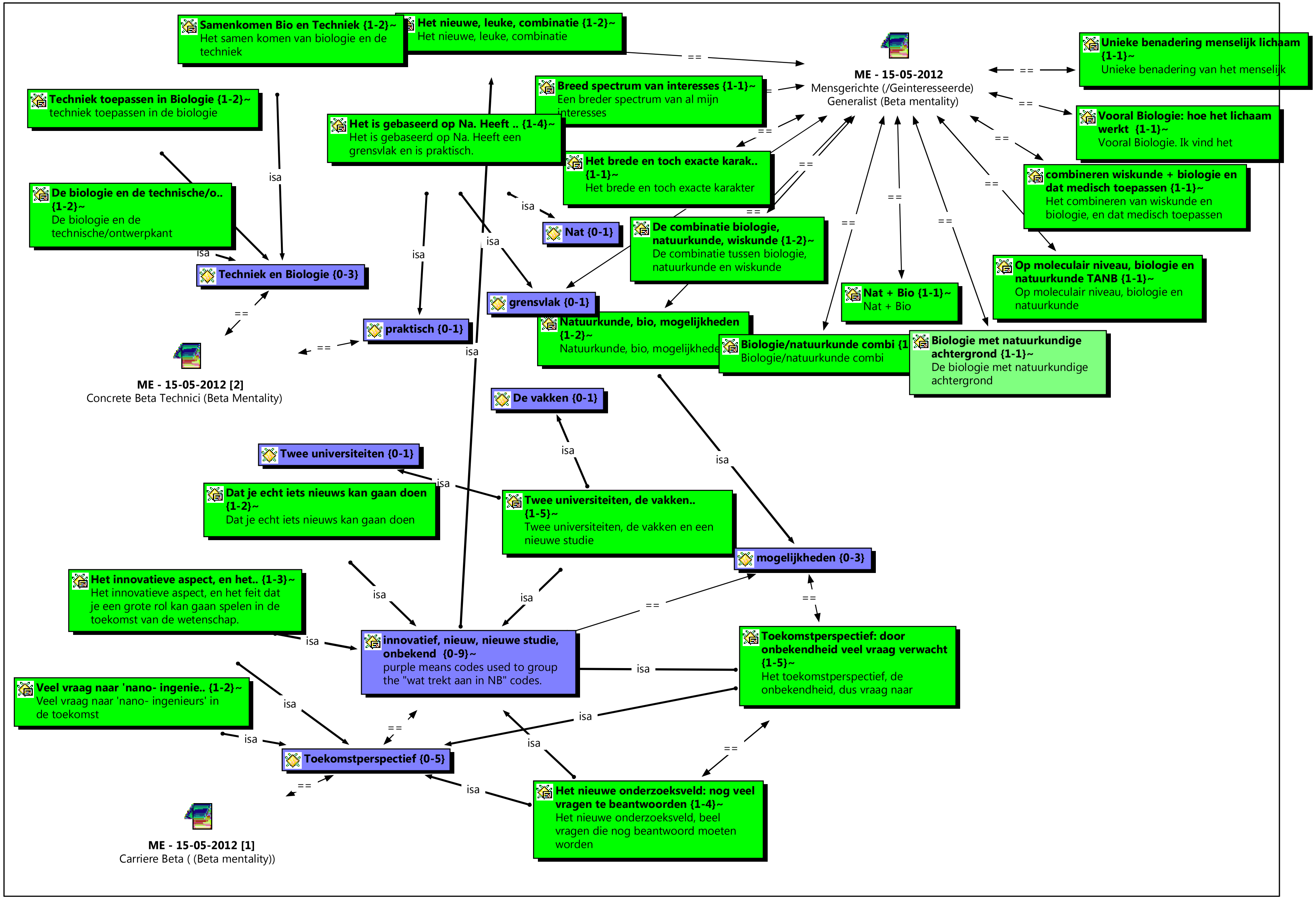
Maatschappelijk relevant
Maatschappelijke relevantie van wetenschappelijk onderzoek
Maatschappelijke verantwoordelijkheid van wetenschappers.

<u>Locatie:</u>

TU Delft
Erasmus Universiteit Rotterdam

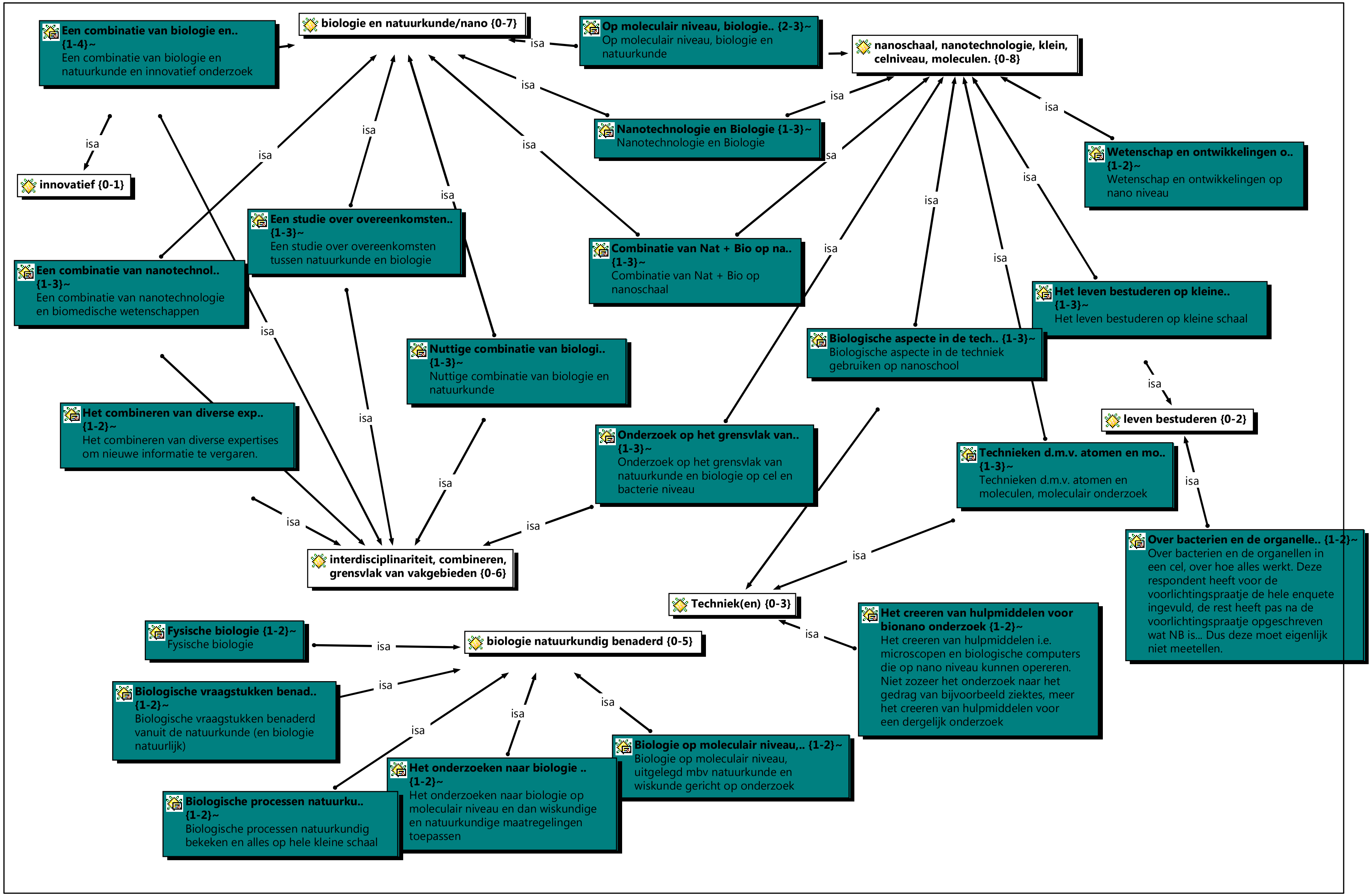
Appendix 6 Outcome information day open question: "what is attractive about Nanobiology?" Used as input for final Questionnaire

Wat trekt aan in Nanobiologie Bachelor 2



Appendix 7 Outcome information day open question: "what is Nanobiology?" Used as input for final Questionnaire

Wat is NB antwoorden infomiddag enquete



Appendix 8 Codes and code family labels: result of Atlas Ti analysis of promotion material (see Appendix 14)

Bold terms represent the family codes or core Nanobiology constructs. Behind brackets are {the number of fragments - the number of connections to other fragments}. *~Means there were memo's inserted by the researcher with these codes as well.*

Interdisciplinair, geïntegreerd {62-1}

Wiskundige en natuurkundige principes {1-2}

Understanding biology from first principles of physics {3-2}~

Kwantitatieve biologie {13-5}~

Fysische processen op celniveau {9-3}~

Nat, Wis, Bio, Gnsk, {61-5}~ *(I combined all these at one point, but decided it's better to take them apart again)*

Scheikunde {1-1}

(Moleculaire) biologie {37-4}~

(Moleculaire basis van) gezondheid en ziekte {10-3}~

Biomedische vraagstukken {3-1}

(Nieuwe) medicijnen {7-1}

Hoe werkt leven {11-1}

Levende systemen {8-2}

Levende cellen {3-3}~

Levende organismen {2-2}

Levende organismen manipuleren {6-1}~

Celniveau {8-3}

Single molecules {6-3}~

DNA {8-2}

Nano (wetenschap) {31-1}

Programmeren/ modelleren in de computer {4-1}

Moeilijk {5-1}

Techniek/Technologie {8-0}~

Toegepaste wetenschap {11-1}

Met technische apparaten werken {1-2}

Microscopen {5-2}

Laboratoriumwerk {15-2}~

Wetenschap, (wetenschappelijk) onderzoek doen {10-2}

Fundamenteel {19-1}

Maatschappelijk relevant {2-0}

Nieuw {20-0}~

Nieuw wetenschappelijk veld {27-0}

Internationaal {6-0}~

Engels {4-0}~

Some examples of how tekst fragments from the promotion documents were connected to codes in Atlas Ti is given on the next pages.

Codes-quotations list
Code-Filter: All [58]

Code: {0-0}

Code: (Moleculaire basis van) gezondheid en ziekte {10-3}~
P 1: open days Martin Depken - 1:27 [So, having given you two examp..] (9:9) (Super)
Codes: [(Moleculaire basis van) gezondheid en ziekte]
So, having given you two examples of the things we do here, I will now tell you a little bit about what Nanobiology, the skills you learn, might be useful, as you come out.(niet zo duidelijk wat hij hier zegt) Its obviously useful for medical diagnostics, this is one big thing, you can actually visualize the molecular course of a disease that would be wonderful tool.
P 1: open days Martin Depken - 1:50 [, its never really going to go..] (16:16) (Super)
Codes: [(Moleculaire basis van) gezondheid en ziekte] [(nieuwe) medicijnen] [fundamenteel] [nano (wetenschap)]
, its never really going to go out of fashion, it has to do with human health, and it has to do with trying to understand things better than we do now and we have to then go to smaller scales.
P 5: Informatiedossier Nanobiologie Oktober 2011.pdf - 5:9 [moleculaire basis van gezondhe..] (8:1368-8:1409) (Super)
Codes: [(Moleculaire basis van) gezondheid en ziekte]
moleculaire basis van gezondheid en ziekte
P 5: Informatiedossier Nanobiologie Oktober 2011.pdf - 5:21 [moleculaire basis van gezondhe..] (8:2422-8:2465) (Super)
Codes: [(Moleculaire basis van) gezondheid en ziekte]
moleculaire basis van
gezondheid en ziekte
P 5: Informatiedossier Nanobiologie Oktober 2011.pdf - 5:29 [fundamentele aspecten van mens..] (9:494-9:553) (Super)
Codes: [(Moleculaire basis van) gezondheid en ziekte] [fundamenteel]
fundamentele aspecten van menselijke
gezondheid en ziekte
P 6: Intro-nanobio_final 2011-03-20 copy.pdf - 6:6 [Nanobiology will provide new u..] (1:664-1:780) (Super)
Codes: [(Moleculaire basis van) gezondheid en ziekte] [(nieuwe) medicijnen]
Nanobiology will provide new
understanding of human health and disease that can potentially revolutionize Medicine.
P 6: Intro-nanobio_final 2011-03-20 copy.pdf - 6:12 [The Erasmus University Medical..] (1:1838-1:2080) (Super)
Codes: [(Moleculaire basis van) gezondheid en ziekte] [(Moleculaire) biologie] [fundamenteel] [Kwantitatieve biologie] [nano (wetenschap)]
The Erasmus University Medical Center Biomedical Sciences Division
encompasses fundamental biology research related to human health and disease, which
increasingly focuses at the nanoscale and requires sophisticated quantitative analysis.
P 6: Intro-nanobio_final 2011-03-20 copy.pdf - 6:19 [first principles quantitative ..] (1:2978-1:3102) (Super)

Appendix 9 Summary of code discussion with Grünwald & Montpetit

Summary of (content) element discussion with David Grünwald and Ben Montpetit (18 May 2011) based on the list of codes and family codes composed using the Atlas Ti analysis of promotion documents (see Appendix 16).

Light blue: summary of the discussion

Black: Link to Atlas ti (family) code (Appendix 16)

==

Fundamental:

Definition/Operationalization:

Basic questions.

Getting to the bottom of how things work. In particular: how the laws of physics govern biological processes on the cellular (or nano) level.

Includes:

Fundamenteel {19-1}

==

Interdisciplinary (PS: After discussing the questionnaire with Caroline Wehrmann this construct was divided into: interdisciplinarity 'as such' and this specific type of interdisicplinarity; physics and molecular biology):

Definition: Two scientific cultures (molecular biology/medicine and physics/engineering); two universities.

Becoming a translator; being educated in two fields so you can understand both. Integrating knowledge/perspectives/language/culture from two scientific fields. **Understanding the physical laws/principles governing biological processes at the molecular/nano scale (i.e. Mathematical and Physical principles applied to Molecular Biology (biological processes at the cellular and molecular level (in order to understand them better))**

Includes:

Physical processes at the cellular level (i.e. Cellular processes driven by thermodynamics) = Quantitative biology = Mathematical and physical principles applied to biology (i.e. Mathematics and Physics with a reason → understanding molecular biology).

Interdisciplinair, geïntegreerd {62-1}

Wiskundige en natuurkundige principes {1-2}

Understanding biology from first principles of physics {3-2}~

Fysische processen op celniveau {9-3}~

Kwantitatieve biologie {13-5}~

==

Societal relevance

Definition: (It's an emerging scientific field)

It enables future medical breakthroughs

Includes:

Maatschappelijk relevant {2-0}

==

Course body

The four big themes (called clouds) that form the heart of the curriculum:

Applied Physics type courses

Theoretical Physics type courses,

Lab practice "labwork" centered courses,

Biology Based courses

Mathematics (like in a physics curriculum)

Nat, Wis, Bio, Gnsk, {61-5}~ (*Dit begrip moet je weer uit elkaar halen, in alle deelelementen, en dan groeperen onder "combineren van al die gebieden"*)

Chemistry/ Biochemistry (just a bit of it)

Scheikunde {1-1}

==

Moeilijk {5-1}

==

Molecular biology:
= Molecular basis of health and disease = health (i.e. geneeskunde?) = basic medical research (= preparation for bench to bedside research (medical field drives molecular biology research. Example: how does immune response work) fundamental medicine) = how does live work = biology (Biology ~study of life → molecular biology ~how does live work) = living systems = living cells = living organisms = 'Nano(biology, Nanobiology ~molecular biology)' = cellular level = single molecules = DNA

Includes:

(Moleculaire) biologie {37-4}~

(Moleculaire basis van) gezondheid en ziekte {10-3}~

Biomedische vraagstukken {3-1}

(Nieuwe) medicijnen {7-1}

Hoe werkt leven {11-1}

Levende systemen {8-2}

Levende cellen {3-3}~

Levende organismen {2-2}

Celniveau {8-3}

Single molecules {6-3}~

DNA {8-2}

==

Innovative

Definition, operationalization

New/innovative study program

- Education integrating two scientific disciplines traditionally taught separately
- Educating a new type of scientist/engineer who is able to operate in the newly emerging (newly opening up) interdisciplinary scientific field Nanobiology (=molecular biophysics= medical physics)

- New (ambitious) pioneering program, searching pioneers who want to pioneer together with a brandnew program
- Using innovative teaching methods
- Program is just starting up so lots of room for students to contribute, influence, interact with the program and staff

Includes:

Nieuw {20-0}~

Nieuw wetenschappelijk veld {27-0}

==

Science!

Definition, operationalization

Not a medical school or engineering pur sang, but a smart combination preparing you for science in this new field (or being a technician etc. Or the other alternatives).

Includes:

Wetenschap, (wetenschappelijk) onderzoek doen {10-2}

==

Nanotechnology as a context for understanding biology:

Definition, operationalization

Not as a justification in itself! (you don't want the people who just like to build nanorobots and that's it.)

Nano (wetenschap) {31-1}

==

International

English

Internationaal {6-0}~

Engels {4-0}~

==

Defined exit strategy after Bsc.

Definition, operationalization

Relevant internship of choice in state of the art research labs and access to its scientific equipment.

==

Lab work

Includes:

Laboratoriumwerk {15-2}~

==

Manipulating/Engineering living systems at the nanoscale/molecular scale using nanotechnology

Includes:

Technical/Technology (should this word be mentioned separately?) = Engineering

Techniek/Technologie {8-0}~

Met technische apparaten werken {1-2}

Microscopen {5-2}

Levende organismen manipuleren {6-1}~

Toegepaste wetenschap {11-1}

==

Programming! Making models in the computer!

Includes:

Programmeren/ modelleren in de computer {4-1}

==

Interesting/dynamic/fresh atmosphere because:

- New, pioneering,
- teachers come from new interdisciplinary Bionanoscience department at an established physics university and from medical school that is starting its first bachelors program ever

- A lot of group work
- Lots of student – teacher interaction
- Exciting new scientific field

Appendix 10 Connection choice factors – Nanobio constructs – questionnaire items.

Factors influencing study choice in general	Factors influencing N-profile students to *not* choose a "beta" study (Langen)	Factors influencing TU Delft choosers study choice in general	Nanobio Construct	Nanobio sub construct	Survey questions
			Element to be explored: Nano	- Nano - Nanotechnology - Nanoscience - Nanobiology	Open question Statement: *"This is attractive to me"* 12) Nanowetenschap 14) Sleutelen aan levende organismen op moleculaire schaal om ze te verbeteren
Content: interesting?			**Content elements :** Math and Physics courses and some chemistry	- Applied Physics - Theoretical Physics - Mathematics	Statement: *"This is attractive to me"* 1) Technische/toegepaste Natuurkunde 2) Theoretische Natuurkunde 3) Scheikunde 8) Wiskunde B
			Content elements : Molecular Biology		4) Celbiologie (bouw en werking van levende cellen op moleculair niveau: DNA, eiwitten etc.) 5) Genetica 6) Evolutie 7) Medische wetenschap 22) Nanotechnologie toepassen in biologie op celniveau om te onderzoeken hoe 'leven' werkt
			Content elements : Programming		10) Programmeren: een wiskundig model bouwen van een levend organisme met de computer
			Content elements : Labwork		15) Laboratoriumwerk
			Content elements ? Interdisciplinary: combining physics and (molecular) biology		9) Natuurkunde, wiskunde, techniek en biologie combineren 11) De complexe biologische levensprocessen in cellen met behulp van natuurkunde begrijpen 13) Onderzoeksmethoden van de natuurkundige en biologische wetenschappen leren combineren 20) Natuurkunde en biologie combineren en medisch toepassen (bijv: nieuwe medicijnen) 19) Grondig begrijpen hoe gezondheid en ziekte werken op het niveau van moleculen 17) Onderzoek op het grensvlak van techniek,

					biologie en medische wetenschap 18)Wetenschappelijke biologie en natuurkunde vakken op basis van complexe wiskunde 24) Opgeleid worden in de twee 'culturen' van techneuten enerzijds en medische wetenschappers anderzijds
			Content elements ? Fundamental		16) Fundamentele kennis: dingen tot op de bodem uitzoeken
			Content elements ? Scientific		23) Goed wetenschappelijk onderzoek leren doen
			Content elements ? Technical/ Technology		21) Techniek: werken met en begrijpen van apparaten (zoals specialistische microscopen)
			Other elements New/Innovative		25) Pionieren in een nieuw onderzoeksveld: opgeleid worden tot een nieuw type wetenschap-per (met een uniek pakket kennis en vaardigheid) 26) Gloednieuwe opleiding 28) Innovatieve opleiding 29) Bijdragen aan de nieuwste ontwikkelingen in de biomedische wetenschap 32) Inspraak in de inrichting van de opleiding 34) Veel interactie tussen docenten en studenten
			Other elements	- Internationally oriented - Teamwork - Specialist study - Designed so that exit to job market is possible with Bsc.	37) College in het Engels 36) Internationaal gericht 27) Specialistische opleiding 30) Specialisatiestage naar keuze in een geavanceerd onderzoekslaboratorium in het derde jaar. (*see also below, copied*) 31) Mogelijkheid om met je bachelor-diploma de arbeidsmarkt op te kunnen gaan. 33) Veel werken in groepjes 38) College aan twee universiteiten (Delft en Erasmus Rotterdam)
			Other elements : Difficult/demanding dedication		35) Uitdagende studie die veel inzet vraagt "Een opleiding met deze 38 kenmerken vind *ik* moeilijk/uitdagend." (*copy, see also below*)

Content: fits with capacities?					- "Een opleiding met deze 38 kenmerken is <u>past bij wat *ik* kan</u>." Statement: <u>"I'm good at this":</u> - Natuurkunde - Biologie - Wiskunde B - Natuurkunde, wiskunde, techniek en biologie combineren - Goed wetenschappelijk onderzoek leren doen - Laboratoriumwerk - Programmeren: een wiskundig model bouwen met de computer - Techniek: werken met en begrijpen van apparaten
Future career: broad?					"Een opleiding met deze 38 kenmerken biedt *mij* een <u>breed</u> beroepsperspectief." "Een opleiding voor bovenstaande beroepen biedt mij een <u>breed</u> beroepsperspectief."
Future career: attractive?					**<u>Stelling: "ik vind dit beroep aantrekkelijk"</u>** - Wetenschapper in nieuw veld op grensvlak natuurkunde, nano- en biomedische wetenschap - Wetenschapper aan een technische universiteit - Wetenschapper aan een medische instelling: bijvoorbeeld ontwikkeling nieuwe medicijnen - Onderzoeker in de pharmaceutische industrie - Onderzoeker in een technisch bedrijf - Laboratorium medewerker. (Analist) - Een "bruggenbouwer" tussen wetenschap en bedrijven - Een "bruggenbouwer" tussen verschillende wetenschappen - Wetenschapsjournalist - Wetenschapsadviseur (bijvb. bij de overheid) - Docent op een middelbare school - Technisch commercieel medewerker in een bedrijf dat apparaten verkoopt aan instellingen in de life sciences "Een opleiding voor bovenstaande beroepen biedt mij een <u>aantrekkelijk</u> beroepsperspectief." (*see also below*, *copied*) - "Een opleiding met deze 38 kenmerken biedt *mij* een <u>aantrekkelijk</u> beroepsperspectief." (*see also below*, *copied*)
Future career: chance to actually be hired in a job?					"Een opleiding met deze 38 kenmerken biedt je in het algemeen een <u>goede kans</u> op een baan." (*see also below, copied*) "Een opleiding voor bovenstaande beroepen biedt mij een <u>goede kans</u> op een baan." (*see also below, copied*)
	No attractive job/career				*See above*

	opportunities				
	Too hard				Copy: "Een opleiding met deze 38 kenmerken vind *ik* moeilijk/uitdagend."
	Too theoretical				"Een opleiding met deze 38 kenmerken vind *ik* erg theoretisch."
	Not focused enough on societal relevance				"Een opleiding met deze 38 kenmerken vind *ik* maatschappelijk gericht."
	Too narrow/ one-sided/not diverse enough				"Een opleiding met deze 38 kenmerken vind *ik* veelzijdig." Copy: the whole "interdisciplinary" construct
		Preparation for future use of study in practice			30) Specialisatiestage naar keuze in een geavanceerd onderzoekslaboratorium in het derde jaar. (*see also above, copied*)
		More chances for a job after the educa-tional program			"Een opleiding voor bovenstaande beroepen biedt mij een goede kans op een baan." (*see also above, copied*) "Een opleiding met deze 38 kenmerken biedt je in het algemeen een goede kans op een baan." (*see also below, copied*)
		Scientific training			Copy: the whole "scientific" construct
		Higher income after this educational program			*Note remark of last test person: "Aantrekkelijk in een baan betekent voor mij dat het een goed betaalde baan is!"*
Extra factors: that might start to play a bigger role concerning the economic and political developments:				Specialized, defined exit after Bsc → possible to enter job market without masters degree	Copy: *specialized* and *exit after Bsc.* And *specialization internship in 3rd year.*
Factors influencing student success likelihood					"Een opleiding met deze 38 kenmerken vind *ik* inhoudelijk interessant." "Een opleiding voor bovenstaande beroepen biedt mij een aantrekkelijk beroepsperspectief." (*see also above, copied*) - "Een opleiding met deze 38 kenmerken biedt *mij* een aantrekkelijk beroepsperspectief." (*see also above, copy*)

Appendix 11 Final outcome qualitative analysis Nanobio core constructs, codes and operationalization to questionnaire items.

Nanobiology core constructs and explanations	Operationalization to the questionnaire items
The main course body - Applied Physics - Theoretical Physics - Chemistry - Mathematics B	1) Technische/toegepaste Natuurkunde 2) Theoretische Natuurkunde 3) Scheikunde 8) Wiskunde B
Molecular biology - Molecular basis of health and disease; - Basic medical research; - How does live work - Cellular level, single molecules, DNA - Evolution - Genetics	4) Celbiologie (bouw en werking van levende cellen op moleculair niveau: DNA, eiwitten etc) 5) Genetica 6) Evolutie 7) Medische wetenschap
Science Nanobiology is neither a medical school nor engineering pur sang, but a smart combination preparing you for science in this new field.	23) Goed wetenschappelijk onderzoek leren doen
Fundamental: - Basic questions. - Getting to the bottom of how things work. In particular: how the laws of physics govern biological processes on the cellular (or nano) level.	16) Fundamentele kennis: dingen tot op de bodem uitzoeken 19) Grondig begrijpen hoe gezondheid en ziekte werken op het niveau van moleculen
Nanotechnology as a context for understanding biology: The emphasis is not on Nanotechnology for the sake of nanotechnology. Just building nanorobots is not the aim, rather, the use of Nanotechnology to enable progress and understanding in the field of molecular biology.	22) Nanotechnologie toepassen in biologie op celniveau om te onderzoeken hoe 'leven' werkt 12) Nanowetenschap
Programming Making mathematical models of biological processes in the computer	10) Programmeren: een wiskundig model bouwen van een levend organisme met de computer
Technical **- Technical University** **- Specialized equipment (being enabled by learning enough applied physics etc. to understand how the (specialized) equipment used in biological research works and how it can be improved).** **- Manipulating/Engineering living systems at the nanoscale/molecular scale using nanotechnology** **- Laboratory work** (Learning lab skills necessary for working in a lab as a researcher)	14) Sleutelen aan levende organismen op moleculaire schaal om ze te verbeteren 15) Laboratoriumwerk 21) Techniek: werken met en begrijpen van apparaten (zoals specialistische microscopen)
Hard, Difficult	35) Uitdagende studie die veel inzet vraagt
Interdisciplinary - Two scientific cultures (molecular biology/medicine and physics/engineering); - Two universities. - Becoming a translator: being educated in two fields so you can understand both. Integrating	9) Natuurkunde, wiskunde, techniek en biologie combineren 20) Natuurkunde en biologie combineren en medisch toepassen (bijv: nieuwe medicijnen) 17) Onderzoek op het grensvlak van techniek,

knowledge/perspectives/language/culture from two scientific fields. - Understanding the physical laws/principles governing biological processes at the molecular/nano scale (i.e. Mathematical and Physical principles applied to Molecular Biology	biologie en medische wetenschap 18)Wetenschappelijke biologie en natuurkunde vakken op basis van complexe wiskunde 13) Onderzoeksmethoden van de natuurkundige en biologische wetenschappen leren combineren 11) De complexe biologische levensprocessen in cellen met behulp van natuurkunde begrijpen 24) Opgeleid worden in de twee 'culturen' van techneuten enerzijds en medische wetenschappers anderzijds 38) College aan twee universiteiten (Delft en Erasmus Rotterdam)
Innovative New/innovative study program – Education integrating two scientific disciplines traditionally taught separately – Educating a new type of scientist/engineer who is able to operate in the newly emerging interdisciplinary scientific field Nanobiology – New (ambitious) pioneering program, searching pioneers who want to pioneer together with a brandnew program – Using innovative teaching methods – Program is just starting up so lots of room for students to contribute, influence, interact with the program and staff	25) Pionieren in een nieuw onderzoeksveld: opgeleid worden tot een nieuw type wetenschap-per (met een uniek pakket kennis en vaardigheid) 26) Gloednieuwe opleiding 28) Innovatieve opleiding 29) Bijdragen aan de nieuwste ontwikkelingen in de biomedische wetenschap 32) Inspraak in de inrichting van de opleiding 33) Veel werken in groepjes 34) Veel interactie tussen docenten en studenten
International - Lessons in English - International teachers (with an international network, which could be helpful for organizing international internships etc.) - Oriented at the international scientific job market.	36) Internationaal gericht 37) College in het Engels
Defined exit strategy after Bsc. Relevant internship of choice in state of the art research labs and access to its scientific equipment. This gives opportunities to enter the labour market with a Bsc. Diploma.	27) Specialistische opleiding 30) Specialisatiestage naar keuze in een geavanceerd onderzoekslaboratorium in het derde jaar 31) Mogelijkheid om met je bachelor-diploma de arbeidsmarkt op te kunnen gaan.

Quick English translation of operationalized items

Nanobiology core constructs and explanations	**Operationalization to the questionnaire items**
The main course body - Applied Physics - Theoretical Physics - Chemistry - Mathematics B	1) Applied physics 2) Theoretical physics 3) Chemistry 8) Mathematics B
Molecular biology - Molecular basis of health and disease; - Basic medical research; - How does live work - Cellular level, single molecules, DNA - Evolution - Genetics	4) Celbiology 5) Genetics 6) Evolution 7) Medical science
Science Nanobiology is neither a medical school nor engineering pur sang, but a smart combination preparing you for science in this new field.	23) Learning to do scientific research really well
Fundamental: - Basic questions. - Getting to the bottom of how things work. In particular: how the laws of physics govern biological processes on the cellular (or nano) level.	16) Fundamental knowledge 19) Fundamental understanding of health and disease
Nanotechnology as a context for understanding biology: The emphasis is not on Nanotechnology for the sake of nanotechnology. Just building nanorobots is not the aim, rather, the use of Nanotechnology to enable progress and understanding in the field of molecular biology.	12) Nanoscience 22) Nanotechnology applied to biology to research how 'life' works
Programming Making mathematical models of biological processes in the computer	10) Programming: building a mathematical model of a living organism using the computer
Technical - Technical University - Specialized equipment (being enabled by learning enough applied physics etc. to understand how the (specialized) equipment used in biological research works and how it can be improved). -_Manipulating/Engineering living systems at the nanoscale/molecular scale using nanotechnology - Laboratory work (Learning lab skills necessary for working in a lab as a researcher)	14) Engineering organisms 15) Laboratory work 21) Technical: working with and understanding equipment (such as specialist microscopes)
Hard, Difficult	35) Challenging program

Interdisciplinary - Two scientific cultures (molecular biology/medicine and physics/engineering); - Two universities. - Becoming a translator: being educated in two fields so you can understand both. Integrating knowledge/perspectives/language/culture from two scientific fields. - Understanding the physical laws/principles governing biological processes at the molecular/nano scale (i.e. Mathematical and Physical principles applied to Molecular Biology	9) Combining physics, mathematics, technology and biology 11) Understanding celbiology using physics 13) Combining research methods from physics and biology 17) Research at the medical/ technological/biological borderline 18) Mathematics based biology and physics 20) Combining physics and biology for health applications 24) Being educated in two scientific cultures 38) Lectures at two universities
Innovative New/innovative study program – Education integrating two scientific disciplines traditionally taught separately – Educating a new type of scientist/engineer who is able to operate in the newly emerging interdisciplinary scientific field Nanobiology – New (ambitious) pioneering program, searching pioneers who want to pioneer together with a brandnew program – Using innovative teaching methods – Program is just starting up so lots of room for students to contribute, influence, interact with the program and staff	25) Pioneering in a new scientific field as a new type of researcher 26) Brandnew program 28) Innovative program 29) Contribute to newest biomedical science developments 32) Contribute to program development 33) Lots of groupwork 34) Lots of teacher - student interaction
International - Lessons in English - International teachers (with an international network, which could be helpful for organizing international internships etc.) - Oriented at the international scientific job market.	36) Internationally oriented 37) Lectures in English
Defined exit strategy after Bsc. Relevant internship of choice in state of the art research labs and access to its scientific equipment. This gives opportunities to enter the labour market with a Bsc. Diploma.	27) Specialist program 30) Specialist laboratory research internship 31) Possibility to enter the job market after the Bsc.

Appendix 12 Descriptive statistics for al metric variables, including factor scale scores and GPA's: N, Mean, SD, Min, Max

Appendix table 5: Descriptive statistics for all metric variables, average scales factor scores and averaged sets of grades.

Descriptive Statistics

Variable	N	Mean	Std. Deviation	Minimum	Maximum
1) Applied physics	429	2,86	1,359	1	5
2) Theoretical physics	430	2,38	1,207	1	5
3) Chemistry	427	3,15	1,184	1	5
4) Cell biology	432	3,07	1,246	1	5
5) Genetics	427	3,32	1,145	1	5
6) Evolution	431	3,26	1,210	1	5
7) Medical sciences	426	3,46	1,294	1	5
8) Mathematics B	423	2,78	1,282	1	5
9) Combining ph, math, techn, bio	437	3,09	1,228	1	5
10) Programming	428	2,36	1,233	1	5
11) Understanding cell biology with physics	429	2,48	1,122	1	5
12) Nanoscience	386	2,88	1,299	1	5
13) Combining ph and bio research methods	426	2,64	1,115	1	5
14) Engineering organisms	433	3,05	1,305	1	5
15) Laboratory work	434	2,88	1,186	1	5
16) Fundamental knowledge	433	3,21	1,172	1	5
17) Research at tech/bio/medical borderline	435	3,10	1,134	1	5
18) Math based bio and physics	428	2,22	1,151	1	5
19) Fundamental understanding health	437	3,23	1,253	1	5
20) Combining ph and bio for health applications	432	3,18	1,240	1	5
21) Technical	425	2,73	1,236	1	5
22) Nanotechnology applied to biology	422	2,94	1,211	1	5
23) Learning to do scientific research	436	3,22	1,154	1	5
24) Two culture education	437	2,79	1,037	1	5
25) Pioneering in new science	437	3,15	1,172	1	5
26) Brand new program	438	3,14	,961	1	5
27) Specialist program	435	3,64	,926	1	5

Variable	N	Mean	Std. Deviation	Minimum	Maximum
28) Innovative program	429	3,65	,902	1	5
29) Newest biomedical science	436	3,10	1,232	1	5
30) Specialist lab internship	435	3,07	1,233	1	5
31) Job market after BSc	438	3,62	1,054	1	5
32) Contributing to program development	435	3,67	,956	1	5
33) Group work	439	3,49	1,009	1	5
34) Lots of teacher - student interaction	433	4,03	,790	1	5
35) Challenging program	436	3,52	,953	1	5
36) Internationally oriented	437	3,91	,984	1	5
37) Lectures in English	433	3,30	1,286	1	5
38) Two universities	436	2,61	1,201	1	5
39) “38 aspects: interesting”	438	3,06	1,080	1	5
40) “38 aspects: fits capacities”	436	3,08	1,116	1	5
41) “38 aspects: broad career perspectives”	433	3,50	1,019	1	5
42) “38 aspects: attractive career perspectives”	437	3,08	1,133	1	5
43) “38 aspects: good job chances”	434	3,79	,902	1	5
44) “38 aspects: challenging”	438	3,88	,824	1	5
45) “38 aspects: diverse”	438	3,60	,943	1	5
46) “38 aspects: societally oriented”	436	2,90	1,005	1	5
47) “38 aspects: very theoretical”	438	3,36	1,009	1	5
48) Scientist in new ph, nano-, biomedical border field	438	2,61	1,195	1	5
49) Scientist at technical university	437	2,63	1,216	1	5
50) Scientist at medical institute	432	3,01	1,263	1	5
51) Researcher in pharmaceutical industry	435	2,65	1,165	1	5
52) Researcher in technical company	436	2,72	1,247	1	5
53) Laboratory technician	434	2,47	1,121	1	5
54) "Bridge builder" science and companies	435	2,89	1,230	1	5
55) "Bridge builder" between sciences	436	2,76	1,127	1	5

Variable	N	Mean	Std. Deviation	Minimum	Maximum
56) Science journalist	438	2,34	1,168	1	5
57) Scientific advisor (government)	436	2,47	1,229	1	5
58) High school teacher	434	2,00	1,189	1	5
59) Technical commercial staff	436	2,28	1,130	1	5
60) Broad career perspectives	435	3,28	1,046	1	5
61) Attractive career perspectives	434	2,84	1,147	1	5
62) Good job chances	434	3,63	,946	1	5
63) Interesting content	434	4,71	,573	2	5
64) Fits my capacities	433	4,64	,593	2	5
65) Access to attractive jobs	432	4,55	,693	1	5
66) Good job chances	433	4,47	,745	1	5
67) Broad career options	432	4,09	,900	1	5
68) Societally oriented	432	3,51	1,046	1	5
69) Challenging	431	3,71	,886	1	5
70) Diverse	433	4,08	,800	2	5
71) Theoretical	429	3,27	,968	1	5
72) Practical	431	3,98	,825	1	5
73) Other;	33	4,88	,415	3	5
74) Physics	429	3,33	1,161	1	5
75) Biology	427	3,45	1,146	1	5
76) Mathematics B	418	3,24	1,327	1	5
77) Combining ph,math,tech, bio	426	3,22	,957	1	5
78) Learning to do scientific research	428	3,38	,906	1	5
79) Laboratory work	422	3,10	1,049	1	5
80) Programming	430	2,41	1,196	1	5
81) Technics	430	3,17	1,218	1	5
82) Physics	398	6,7206	1,06812	3,00	9,40
83) Mathematics B	339	6,8032	1,22417	3,00	10,00
84) Biology	352	6,8642	,83548	3,80	9,20
85) Chemistry	423	6,5688	1,15503	3,00	9,60
BioMed: 4,5,7,17,19,20,29 averaged	405	3,2310	,94739	1,00	5,00
Average MathB and Physics Grade if they have both, otherwise Mathematics B grade OR Physics grade	404	6,7162	1,03407	3,90	10,00
Grade Point Average of all filled in grades	425	6,7028	,86434	4,43	9,25

Variable	N	Mean	Std. Deviation	Minimum	Maximum
Biology Grade OR Chemistry if no bio	423	6,8317	,90611	3,10	9,30
Unf: 12,14,15,21,22,30 averaged	369	2,9178	,91106	1,00	5,00
Exact: 1,2,3, 8,9,10,18 averaged	395	2,6825	,87935	1,00	5,00
Science: 16,23 averaged	431	3,2169	1,02352	1,00	5,00
Innovative: 25,26,27,28 averaged	423	3,3983	,72163	1,00	5,00
International: 36,37 averaged	431	3,5998	1,03902	1,00	5,00
Hand calculated average score core attraction of program 39+40+42	435	3,0782	,91330	1,00	5,00
Hand calculated average score broadness program 41+43+45	429	3,6270	,74761	1,00	5,00
Hand calculated average score job evaluation 60-62	433	3,2525	,84856	1,00	5,00
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	420	3,3063	,68651	,00	4,89
Science/Technically oriented career average	425	2,6818	,93906	1,00	5,00
Biomedical scientist career average	425	2,6818	,93906	1,00	5,00
Journalist/Advisor average	436	2,4060	1,07012	1,00	5,00

Appendix 13 Normality tests: Kolmogorov Smirnov tests, an example of a Q-Q plot and detrended Q-Q plot, example of histogram

Appendix table 6: Kolmogorov Smirnov test for all metric variables and scales.
Test distribution is Normal.
Normal parameters calculated from data.

Variable	N	Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Absolute	Positive	Negative		
1) Applied physics	429	,210	,183	-,210	4,356	,000
2) Theoretical physics	430	,193	,193	-,127	4,002	,000
3) Chemistry	427	,215	,130	-,215	4,443	,000
4) Cell biology	432	,214	,139	-,214	4,449	,000
5) Genetics	427	,221	,137	-,221	4,574	,000
6) Evolution	431	,216	,130	-,216	4,475	,000
7) Medical sciences	426	,230	,117	-,230	4,743	,000
8) Mathematics B	423	,160	,147	-,160	3,288	,000
9) Combining ph, math, techn, bio	437	,187	,133	-,187	3,916	,000
10) Programming	428	,218	,218	-,135	4,517	,000
11) Understanding cell biology with physics	429	,201	,201	-,143	4,163	,000
12) Nanoscience	386	,166	,147	-,166	3,266	,000
13) Combining ph and bio research methods	426	,183	,183	-,161	3,776	,000
14) Engineering organisms	433	,192	,166	-,192	3,994	,000
15) Laboratory work	434	,180	,131	-,180	3,750	,000
16) Fundamental knowledge	433	,187	,134	-,187	3,900	,000
17) Research at tech/bio/medical borderline	435	,196	,144	-,196	4,097	,000
18) Math based bio and physics	428	,214	,214	-,144	4,433	,000
19) Fundamental understanding health	437	,207	,147	-,207	4,336	,000
20) Combining ph and bio for health applications	432	,214	,155	-,214	4,457	,000
21) Technical	425	,179	,179	-,142	3,688	,000
22) Nanotechnology applied to biology	422	,185	,162	-,185	3,793	,000
23) Learning to do scientific research	436	,195	,135	-,195	4,065	,000
24) Two culture education	437	,189	,175	-,189	3,954	,000
25) Pioneering in new science	437	,198	,121	-,198	4,129	,000
26) Brand new program	438	,211	,191	-,211	4,412	,000

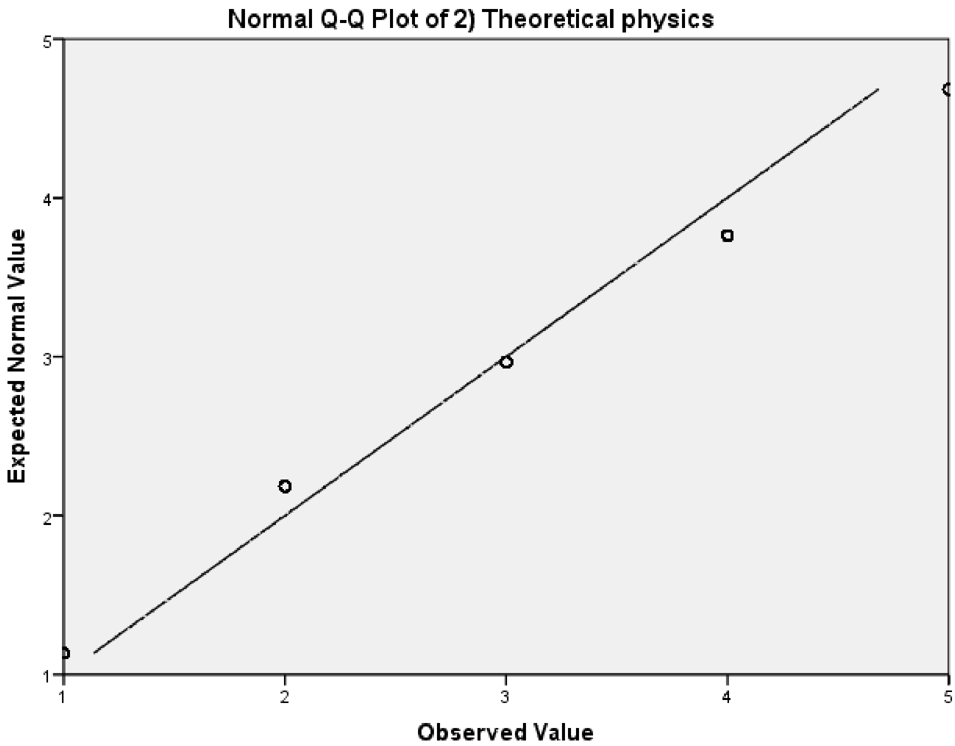
Variable	N	Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Absolute	Positive	Negative		
27) Specialist program	435	,283	,204	-,283	5,901	,000
28) Innovative program	429	,257	,191	-,257	5,313	,000
29) Newest biomedical science	436	,171	,137	-,171	3,579	,000
30) Specialist lab internship	435	,185	,153	-,185	3,865	,000
31) Job market after BSc	438	,239	,149	-,239	4,994	,000
32) Contributing to program development	435	,269	,189	-,269	5,600	,000
33) Group work	439	,221	,159	-,221	4,634	,000
34) Lots of teacher - student interaction	433	,283	,241	-,283	5,884	,000
35) Challenging program	436	,225	,176	-,225	4,692	,000
36) Internationally oriented	437	,221	,138	-,221	4,625	,000
37) Lectures in English	433	,184	,115	-,184	3,826	,000
38) Two universities	436	,187	,187	-,134	3,912	,000
39) "38 aspects: interesting"	438	,214	,140	-,214	4,479	,000
40) "38 aspects: fits capacities"	436	,186	,138	-,186	3,885	,000
41) "38 aspects: broad career perspectives"	433	,248	,167	-,248	5,167	,000
42) "38 aspects: attractive career perspectives"	437	,177	,148	-,177	3,709	,000
43) "38 aspects: good job chances"	434	,265	,198	-,265	5,516	,000
44) "38 aspects: challenging"	438	,291	,232	-,291	6,096	,000
45) "38 aspects: diverse"	438	,275	,191	-,275	5,756	,000
46) "38 aspects: societally oriented"	436	,223	,199	-,223	4,666	,000
47) "38 aspects: very theoretical"	438	,197	,179	-,197	4,127	,000
48) Scientist in new ph, nano-, biomedical border field	438	,184	,184	-,142	3,857	,000
49) Scientist at technical university	437	,178	,178	-,145	3,712	,000
50) Scientist at medical institute	432	,200	,137	-,200	4,161	,000
51) Researcher in pharmaceutical industry	435	,184	,184	-,146	3,832	,000
52) Researcher in technical company	436	,197	,197	-,167	4,113	,000
53) Laboratory technician	434	,192	,192	-,152	4,009	,000
54) "Bridge builder" science and companies	435	,171	,161	-,171	3,560	,000

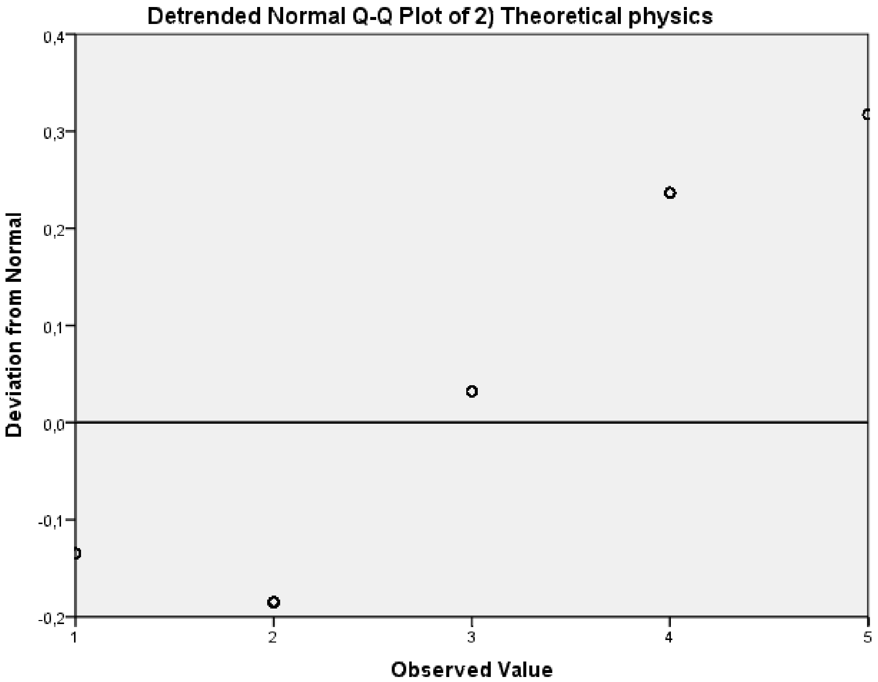
Variable	N	Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Absolute	Positive	Negative		
55) "Bridge builder" between sciences	436	,175	,159	-,175	3,649	,000
56) Science journalist	438	,213	,213	-,125	4,467	,000
57) Scientific advisor (government)	436	,199	,199	-,128	4,151	,000
58) High school teacher	434	,290	,290	-,201	6,032	,000
59) Technical commercial staff	436	,199	,199	-,136	4,165	,000
60) Broad career perspectives	435	,213	,147	-,213	4,444	,000
61) Attractive career perspectives	434	,174	,174	-,155	3,620	,000
62) Good job chances	434	,265	,188	-,265	5,530	,000
63) Interesting content	434	,450	,303	-,450	9,375	,000
64) Fits my capacities	433	,419	,272	-,419	8,716	,000
65) Access to attractive jobs	432	,378	,256	-,378	7,854	,000
66) Good job chances	433	,352	,239	-,352	7,331	,000
67) Broad career options	432	,242	,156	-,242	5,029	,000
68) Societally oriented	432	,187	,181	-,187	3,879	,000
69) Challenging	431	,252	,189	-,252	5,233	,000
70) Diverse	433	,247	,212	-,247	5,145	,000
71) Theoretical	429	,194	,190	-,194	4,022	,000
72) Practical	431	,248	,207	-,248	5,148	,000
73) Other;	33	,524	,385	-,524	3,010	,000
74) Physics	429	,224	,130	-,224	4,646	,000
75) Biology	427	,269	,169	-,269	5,562	,000
76) Mathematics B	418	,207	,117	-,207	4,223	,000
77) Combining ph, math, tech, bio	426	,216	,194	-,216	4,465	,000
78) Learning to do scientific research	428	,230	,185	-,230	4,763	,000
79) Laboratory work	422	,207	,155	-,207	4,256	,000
80) Programming	430	,216	,216	-,124	4,479	,000
81) Technics	430	,201	,145	-,201	4,170	,000
82) Physics	398	,118	,118	-,111	2,353	,000
83) Mathematics B	339	,112	,112	-,077	2,056	,000
84) Biology	352	,134	,134	-,119	2,520	,000
85) Chemistry	423	,097	,097	-,096	1,990	,001
BioMed: 4,5,7,17,19,20,29 averaged	405	,085	,058	-,085	1,706	,006
Unf: 12,14,15,21,22,30 averaged	369	,071	,052	-,071	1,365	,048
Exact: 1,2,3, 8,9,10,18 averaged	395	,072	,072	-,049	1,423	,035
Science: 16,23 averaged	431	,124	,081	-,124	2,575	,000

Variable	N	Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Absolute	Positive	Negative		
Innovative: 25,26,27,28 averaged	423	,097	,079	-,097	2,003	,001
International: 36,37 averaged	431	,128	,089	-,128	2,656	,000
Hand calculated average score core attraction of program 39+40+42	435	,101	,064	-,101	2,112	,000
Hand calculated average score broadness program 41+43+45	429	,134	,106	-,134	2,779	,000
Hand calculated average score job evaluation 60-62	433	,091	,088	-,091	1,902	,001
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	420	,061	,031	-,061	1,245	,090
Science/Technically oriented career average	425	,082	,050	-,082	1,688	,007
Biomedical scientist career average	425	,082	,050	-,082	1,688	,007
Journalist/Advisor average	436	,152	,152	-,101	3,182	,000

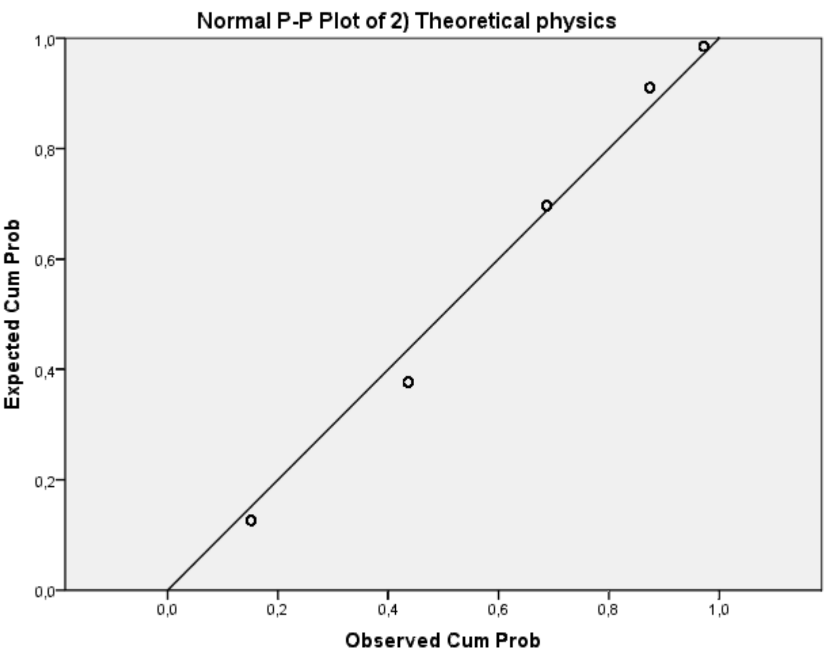
2) Example Q-Q, P-P tests and histogram for non-normal variable "Theoretical physics"

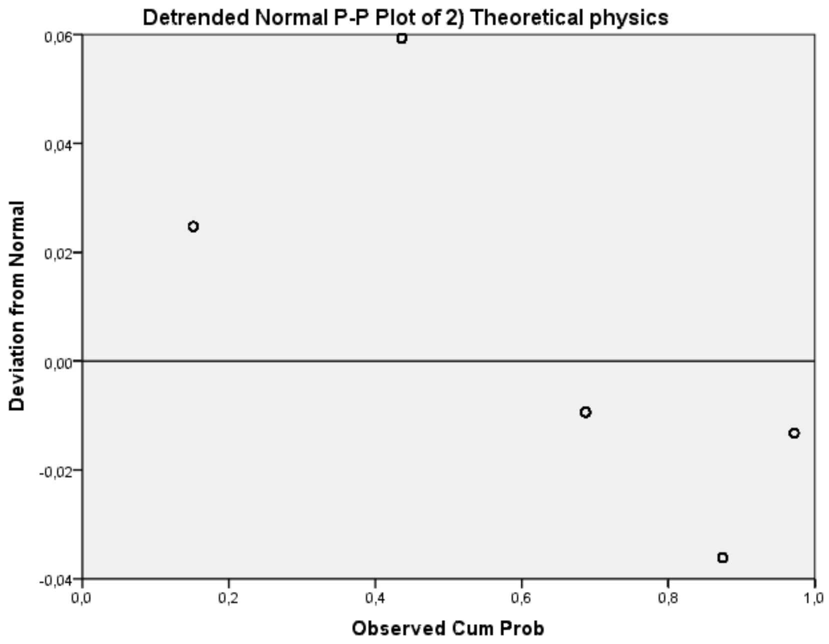
Q-Q plots



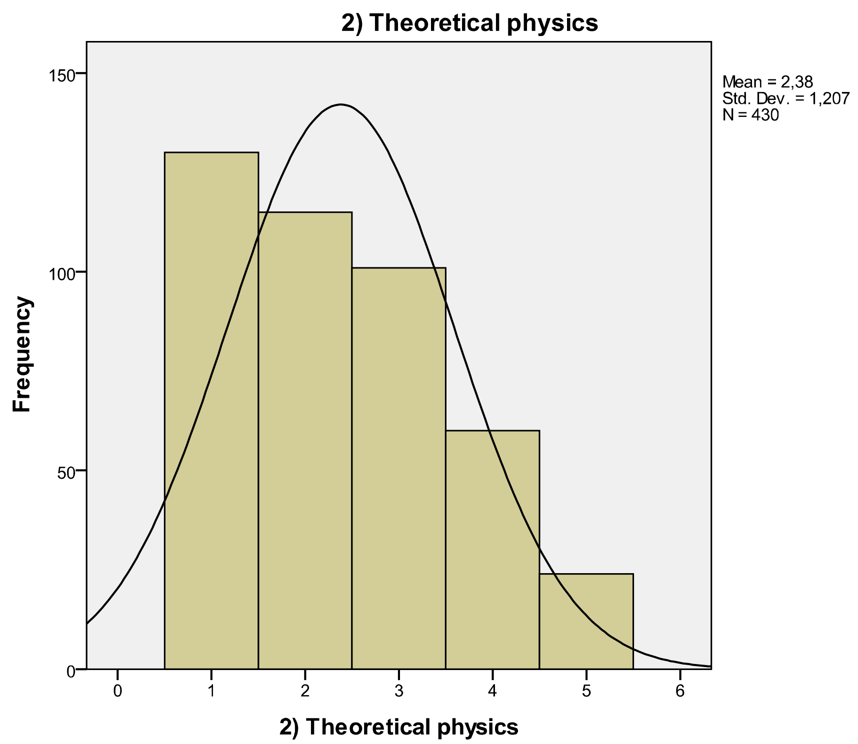

Detrended Normal Q-Q Plot of 2) Theoretical physics
Deviation from Normal
Observed Value
0,4
0,3
0,2
0,1
0,0
-0,1
-0,2
1
2
3
4
5

P-P plots


Normal P-P Plot of 2) Theoretical physics
Expected Cum Prob
Observed Cum Prob
1,0
0,8
0,6
0,4
0,2
0,0
0,0
0,2
0,4
0,6
0,8
1,0



Histogram with normal line



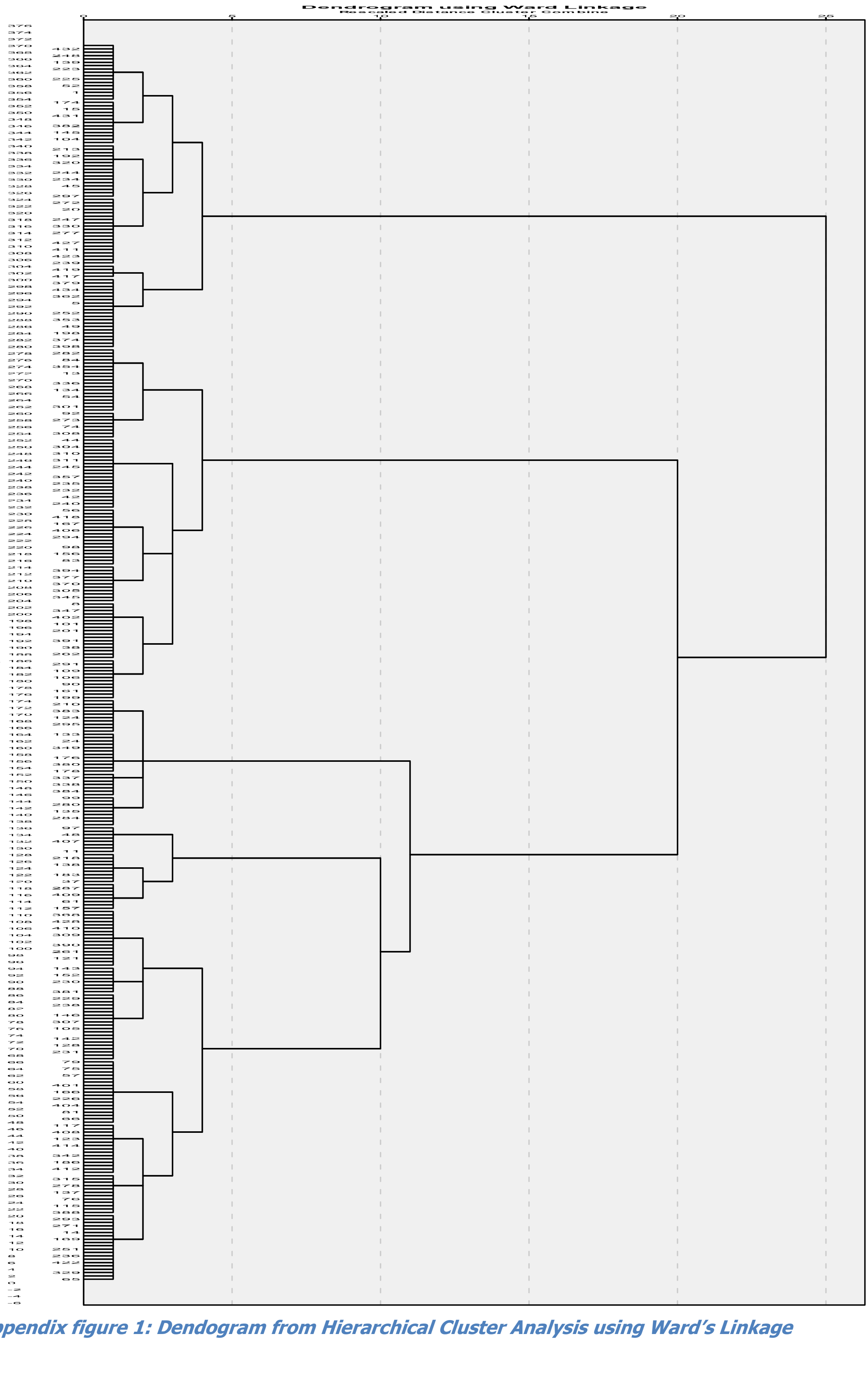
Appendix 14 Cluster Analysis Background: Agglomeration Schedule

Appendix table 7: Cluster Analysis background: Agglomeration Schedule from Hierarchical Cluster Analysis using Ward's Linkage.

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage	Coefficient difference between stages	Correspon-ding # of clusters
	Cluster 1	Cluster 2		Cluster 1	Cluster 2			
356	6	10	1234,754	345	336	364	36,540	
357	24	99	1272,573	347	352	367	37,819	
358	11	32	1313,333	314	354	366	40,760	
359	7	8	1357,538	344	353	362	44,205	
360	1	20	1402,364	349	355	365	44,825	
361	9	57	1448,772	350	334	364	46,408	
362	7	22	1499,453	359	343	363	50,681	
363	7	12	1569,534	362	351	368	70,082	8 clusters
364	6	9	1641,069	356	361	366	71,535	
365	1	5	1716,721	360	346	369	75,652	
366	6	11	1902,228	364	358	367	185,506	5 clusters
367	6	24	2103,949	366	357	368	201,721	
368	6	7	2486,974	367	363	369	383,025	
369	1	6	2981,909	365	368	0	494,935	

Appendix 15 Cluster Analysis Background: Dendogram



Appendix figure 1: Dendogram from Hierarchical Cluster Analysis using Ward's Linkage

Appendix 16 Outcomes of Kruskall-Wallis tests

Appendix table 8: Table of outcomes of the Kruskall-Wallis tests on the 4 clusters: Mean Rank.

Ranks

Variable	Clusters	N	Mean Rank
74) Physics	dream cluster	58	260,19
	risky cluster	70	151,99
	potential cluster	56	261,90
	all the rest	186	151,82
	Total	370	
75) Biology	dream cluster	58	248,94
	risky cluster	70	232,28
	potential cluster	56	244,95
	all the rest	186	130,22
	Total	370	
76) Mathematics B	dream cluster	58	228,00
	risky cluster	70	77,99
	potential cluster	56	307,14
	all the rest	186	176,09
	Total	370	
Average MathB and Physics Grade if they have both, otherwise Mathematics B grade OR Physics grade	dream cluster	58	262,91
	risky cluster	70	119,45
	potential cluster	56	308,57
	all the rest	186	149,17
	Total	370	
Grade Point Average of all filled in grades	dream cluster	58	273,45
	risky cluster	70	123,74
	potential cluster	56	306,51
	all the rest	186	144,89
	Total	370	
Biology Grade OR Chemistry if no bio	dream cluster	58	244,56
	risky cluster	70	168,97
	potential cluster	56	269,74
	all the rest	186	147,94
	Total	370	
Science/Technically oriented career average	dream cluster	56	261,63
	risky cluster	69	221,59
	potential cluster	55	153,87
	all the rest	181	148,83
	Total	361	
Biomedical scientist career average	dream cluster	56	261,63
	risky cluster	69	221,59
	potential cluster	55	153,87
	all the rest	181	148,83
	Total	361	
Journalist/Advisor average	dream cluster	57	195,41
	risky cluster	70	218,26
	potential cluster	56	151,15
	all the rest	185	178,46
	Total	368	

Variable	Clusters	N	Mean Rank
Hand calculated average score core attraction of program 39+40+42	dream cluster	58	297,58
	risky cluster	70	245,19
	potential cluster	56	174,87
	all the rest	186	131,29
	Total	370	
Hand calculated average score broadness program 41+43+45	dream cluster	58	270,34
	risky cluster	70	241,16
	potential cluster	56	130,91
	all the rest	186	154,53
	Total	370	
Hand calculated average score job evaluation 60-62	dream cluster	58	253,88
	risky cluster	70	264,01
	potential cluster	56	120,52
	all the rest	186	154,20
	Total	370	
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	dream cluster	58	297,87
	risky cluster	70	273,03
	potential cluster	56	130,71
	all the rest	186	134,02
	Total	370	
BioMed: 4,5,7,17,19,20,29 averaged	dream cluster	54	246,32
	risky cluster	67	211,55
	potential cluster	53	160,26
	all the rest	169	136,25
	Total	343	
Unf: 12,14,15,21,22,30 averaged	dream cluster	54	221,31
	risky cluster	59	195,86
	potential cluster	51	144,05
	all the rest	149	122,74
	Total	313	
Exact: 1,2,3, 8,9,10,18 averaged	dream cluster	54	249,01
	risky cluster	66	131,17
	potential cluster	52	191,35
	all the rest	169	155,37
	Total	341	
Science: 16,23 averaged	dream cluster	58	243,71
	risky cluster	69	193,78
	potential cluster	56	168,96
	all the rest	182	163,89
	Total	365	
Innovative: 25,26,27,28 averaged	dream cluster	56	235,39
	risky cluster	68	200,49
	potential cluster	55	151,77
	all the rest	177	160,36
	Total	356	
International: 36,37 averaged	dream cluster	58	191,10
	risky cluster	70	210,23
	potential cluster	55	198,79
	all the rest	183	166,27
	Total	366	

Appendix table 9: Table of outcomes of the Kruskall-Wallis tests on the 4 clusters: significance.

Test Statistics a,b

Variable	Chi-Square	df	Asymp. Sig.
74) Physics self efficacy	89,175	3	,000
75) Biology self efficacy	112,512	3	,000
76) Mathematics B self efficacy	162,447	3	,000
Average MathB and Physics Grade if they have both, otherwise Mathematics B grade OR Physics grade	153,402	3	,000
Grade Point Average of all filled in grades	161,208	3	,000
Biology Grade OR Chemistry if no biology grade	78,654	3	,000
Science/Technically oriented career average	65,269	3	,000
Biomedical scientist career average	65,269	3	,000
Journalist/Advisor average	14,139	3	,003
Hand calculated average score core attraction of program 39+40+42	135,746	3	,000
Hand calculated average score broadness program 41+43+45	87,703	3	,000
Hand calculated average score job evaluation 60-62	99,536	3	,000
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	169,190	3	,000
BioMed: 4,5,7,17,19,20,29 averaged	63,841	3	,000
Unf: 12,14,15,21,22,30 averaged	60,730	3	,000
Exact: 1,2,3, 8,9,10,18 averaged	51,191	3	,000
Science: 16,23 averaged	27,450	3	,000
Innovative: 25,26,27,28 averaged	29,813	3	,000
International: 36,37 averaged	11,000	3	,012

Appendix 17 Post-hoc Mann-Whitney U tests: dream vs. risky cluster

Appendix table 10: Mann-Whitney test on dream cluster versus risky cluster: N, Mean Rank and Sum of Ranks

Ranks

Scale	Clusters compared	N	Mean Rank	Sum of Ranks
BioMed: 4,5,7,17,19,20,29 averaged	dream cluster	54	70,17	3789,00
	risky cluster	67	53,61	3592,00
	Total	121		
Unf: 12,14,15,21,22,30 averaged	dream cluster	54	62,91	3397,00
	risky cluster	59	51,59	3044,00
	Total	113		
Exact: 1,2,3, 8,9,10,18 averaged	dream cluster	54	84,18	4545,50
	risky cluster	66	41,13	2714,50
	Total	120		
Science: 16,23 averaged	dream cluster	58	73,74	4277,00
	risky cluster	69	55,81	3851,00
	Total	127		
Innovative: 25,26,27,28 averaged	dream cluster	56	69,38	3885,50
	risky cluster	68	56,83	3864,50
	Total	124		
International: 36,37 averaged	dream cluster	58	60,70	3520,50
	risky cluster	70	67,65	4735,50
	Total	128		
Hand calculated average score core attraction of program 39+40+42	dream cluster	58	78,96	4579,50
	risky cluster	70	52,52	3676,50
	Total	128		
Hand calculated average score broadness program 41+43+45	dream cluster	58	71,42	4142,50
	risky cluster	70	58,76	4113,50
	Total	128		

Scale	Clusters compared	N	Mean Rank	Sum of Ranks
Hand calculated average score job evaluation 60-62	dream cluster	58	61,66	3576,00
	risky cluster	70	66,86	4680,00
	Total	128		
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	dream cluster	58	73,41	4257,50
	risky cluster	70	57,12	3998,50
	Total	128		
Science/Technically oriented career average	dream cluster	56	71,02	3977,00
	risky cluster	69	56,49	3898,00
	Total	125		
Biomedical scientist career average	dream cluster	56	71,02	3977,00
	risky cluster	69	56,49	3898,00
	Total	125		
Journalist/Advisor average	dream cluster	57	59,22	3375,50
	risky cluster	70	67,89	4752,50
	Total	127		
Average MathB and Physics Grade if they have both, otherwise Mathematics B grade OR Physics grade	dream cluster	58	91,16	5287,00
	risky cluster	70	42,41	2969,00
	Total	128		
Grade Point Average of all filled in grades	dream cluster	58	93,08	5398,50
	risky cluster	70	40,82	2857,50
	Total	128		
Biology Grade OR Chemistry if no bio	dream cluster	58	79,58	4615,50
	risky cluster	70	52,01	3640,50
	Total	128		
74) Physics	dream cluster	58	86,50	5017,00
	risky cluster	70	46,27	3239,00
	Total	128		
75) Biology	dream cluster	58	68,47	3971,50
	risky cluster	70	61,21	4284,50
	Total	128		
76) Mathematics B	dream cluster	58	96,06	5571,50
	risky cluster	70	38,35	2684,50
	Total	128		

Appendix table 11: Mann-Whitney test on dream cluster versus risky cluster: Significance

		Test Statistics		
	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
BioMed: 4,5,7,17,19,20,29 averaged	1314,000	3592,000	-2,587	,010
Unf: 12,14,15,21,22,30 averaged	1274,000	3044,000	-1,839	,066
Exact: 1,2,3, 8,9,10,18 averaged	503,500	2714,500	-6,756	,000
Science: 16,23 averaged	1436,000	3851,000	-2,769	,006
Innovative: 25,26,27,28 averaged	1518,500	3864,500	-1,953	,051
International: 36,37 averaged	1809,500	3520,500	-1,071	,284
Hand calculated average score core attraction of program 39+40+42	1191,500	3676,500	-4,091	,000
Hand calculated average score broadness program 41+43+45	1628,500	4113,500	-1,965	,049
Hand calculated average score job evaluation 60-62	1865,000	3576,000	-,805	,421

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	1513,500	3998,500	-2,484	,013
Science/Technically oriented career average	1483,000	3898,000	-2,242	,025
Biomedical scientist career average	1483,000	3898,000	-2,242	,025
Journalist/Advisor average	1722,500	3375,500	-1,338	,181
Average MathB and Physics Grade if they have both, otherwise Mathematics B grade OR Physics grade	484,000	2969,000	-7,422	,000
Grade Point Average of all filled in grades	372,500	2857,500	-7,939	,000
Biology Grade OR Chemistry if no bio	1155,500	3640,500	-4,242	,000
74) Physics	754,000	3239,000	-6,473	,000
75) Biology	1799,500	4284,500	-1,282	,200
76) Mathematics B	199,500	2684,500	-9,002	,000

Appendix 18 Post-hoc Mann-Whitney U tests: dream vs. potential cluster

Appendix table 12: Mann-Whitney test on dream cluster versus potential cluster: N, Mean Rank and Sum of Ranks

Ranks

Scale	Clusters compared	N	Mean Rank	Sum of Ranks
BioMed: 4,5,7,17,19,20,29 averaged	dream cluster	54	67,66	3653,50
	potential cluster	53	40,08	2124,50
	Total	107		
Unf: 12,14,15,21,22,30 averaged	dream cluster	54	65,53	3538,50
	potential cluster	51	39,74	2026,50
	Total	105		
Exact: 1,2,3, 8,9,10,18 averaged	dream cluster	54	61,52	3322,00
	potential cluster	52	45,17	2349,00
	Total	106		
Science: 16,23 averaged	dream cluster	58	68,71	3985,00
	potential cluster	56	45,89	2570,00
	Total	114		
Innovative: 25,26,27,28 averaged	dream cluster	56	68,89	3858,00
	potential cluster	55	42,87	2358,00
	Total	111		
International: 36,37 averaged	dream cluster	58	55,74	3233,00
	potential cluster	55	58,33	3208,00
	Total	113		
Hand calculated average score core attraction of program 39+40+42	dream cluster	58	78,32	4542,50
	potential cluster	56	35,94	2012,50
	Total	114		
Hand calculated average score broadness program 41+43+45	dream cluster	58	77,78	4511,50
	potential cluster	56	36,49	2043,50
	Total	114		

Scale	Clusters compared	N	Mean Rank	Sum of Ranks
Hand calculated average score job evaluation 60-62	dream cluster	58	77,45	4492,00
	potential cluster	56	36,84	2063,00
	Total	114		
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	dream cluster	58	82,71	4797,00
	potential cluster	56	31,39	1758,00
	Total	114		
Science/Technically oriented career average	dream cluster	56	71,55	4007,00
	potential cluster	55	40,16	2209,00
	Total	111		
Biomedical scientist career average	dream cluster	56	71,55	4007,00
	potential cluster	55	40,16	2209,00
	Total	111		
Journalist/Advisor average	dream cluster	57	64,06	3651,50
	potential cluster	56	49,81	2789,50
	Total	113		
Average MathB and Physics Grade if they have both, otherwise Mathematics B grade OR Physics grade	dream cluster	58	47,82	2773,50
	potential cluster	56	67,53	3781,50
	Total	114		
Grade Point Average of all filled in grades	dream cluster	58	49,10	2848,00
	potential cluster	56	66,20	3707,00
	Total	114		
Biology Grade OR Chemistry if no bio	dream cluster	58	52,90	3068,00
	potential cluster	56	62,27	3487,00
	Total	114		
74) Physics	dream cluster	58	56,67	3287,00
	potential cluster	56	58,36	3268,00
	Total	114		
75) Biology	dream cluster	58	57,38	3328,00
	potential cluster	56	57,63	3227,00
	Total	114		
76) Mathematics B	dream cluster	58	40,12	2327,00
	potential cluster	56	75,50	4228,00
	Total	114		

Appendix table 13: Mann-Whitney test on dream cluster versus potential cluster: Significance

		Test Statistics		
	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
BioMed: 4,5,7,17,19,20,29 averaged	693,500	2124,500	-4,602	,000
Unf: 12,14,15,21,22,30 averaged	700,500	2026,500	-4,347	,000
Exact: 1,2,3, 8,9,10,18 averaged	971,000	2349,000	-2,741	,006
Science: 16,23 averaged	974,000	2570,000	-3,723	,000
Innovative: 25,26,27,28 averaged	818,000	2358,000	-4,285	,000
International: 36,37 averaged	1522,000	3233,000	-,424	,671
Hand calculated average score core attraction of program 39+40+42	416,500	2012,500	-6,922	,000
Hand calculated average score broadness program 41+43+45	447,500	2043,500	-6,762	,000
Hand calculated average score job evaluation 60-62	467,000	2063,000	-6,622	,000

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	162,000	1758,000	-8,302	,000
Science/Technically oriented career average	669,000	2209,000	-5,160	,000
Biomedical scientist career average	669,000	2209,000	-5,160	,000
Journalist/Advisor average	1193,500	2789,500	-2,350	,019
Average MathB and Physics Grade if they have both, otherwise Mathematics B grade OR Physics grade	1062,500	2773,500	-3,196	,001
Grade Point Average of all filled in grades	1137,000	2848,000	-2,764	,006
Biology Grade OR Chemistry if no bio	1357,000	3068,000	-1,545	,122
74) Physics	1576,000	3287,000	-,300	,764
75) Biology	1617,000	3328,000	-,044	,965
76) Mathematics B	616,000	2327,000	-6,238	,000

Appendix 19 Post-hoc Mann-Whitney U tests: risky vs. potential cluster

Appendix table 14: Mann Whitney test on risky cluster versus potential cluster: N, Mean Rank and Sum of Ranks

Ranks

Scale	Clusters compared	N	Mean Rank	Sum of Ranks
BioMed: 4,5,7,17,19,20,29 averaged	risky cluster	67	69,10	4629,50
	potential cluster	53	49,63	2630,50
	Total	120		
Unf: 12,14,15,21,22,30 averaged	risky cluster	59	64,13	3783,50
	potential cluster	51	45,52	2321,50
	Total	110		
Exact: 1,2,3, 8,9,10,18 averaged	risky cluster	66	50,71	3347,00
	potential cluster	52	70,65	3674,00
	Total	118		
Science: 16,23 averaged	risky cluster	69	66,83	4611,00
	potential cluster	56	58,29	3264,00
	Total	125		
Innovative: 25,26,27,28 averaged	risky cluster	68	69,54	4729,00
	potential cluster	55	52,67	2897,00
	Total	123		
International: 36,37 averaged	risky cluster	70	65,14	4559,50
	potential cluster	55	60,28	3315,50
	Total	125		
Hand calculated average score core attraction of program 39+40+42	risky cluster	70	75,89	5312,50
	potential cluster	56	48,01	2688,50
	Total	126		
Hand calculated average score broadness program 41+43+45	risky cluster	70	80,34	5624,00
	potential cluster	56	42,45	2377,00
	Total	126		
Hand calculated average score job evaluation 60-62	risky cluster	70	84,54	5917,50
	potential cluster	56	37,21	2083,50
	Total	126		

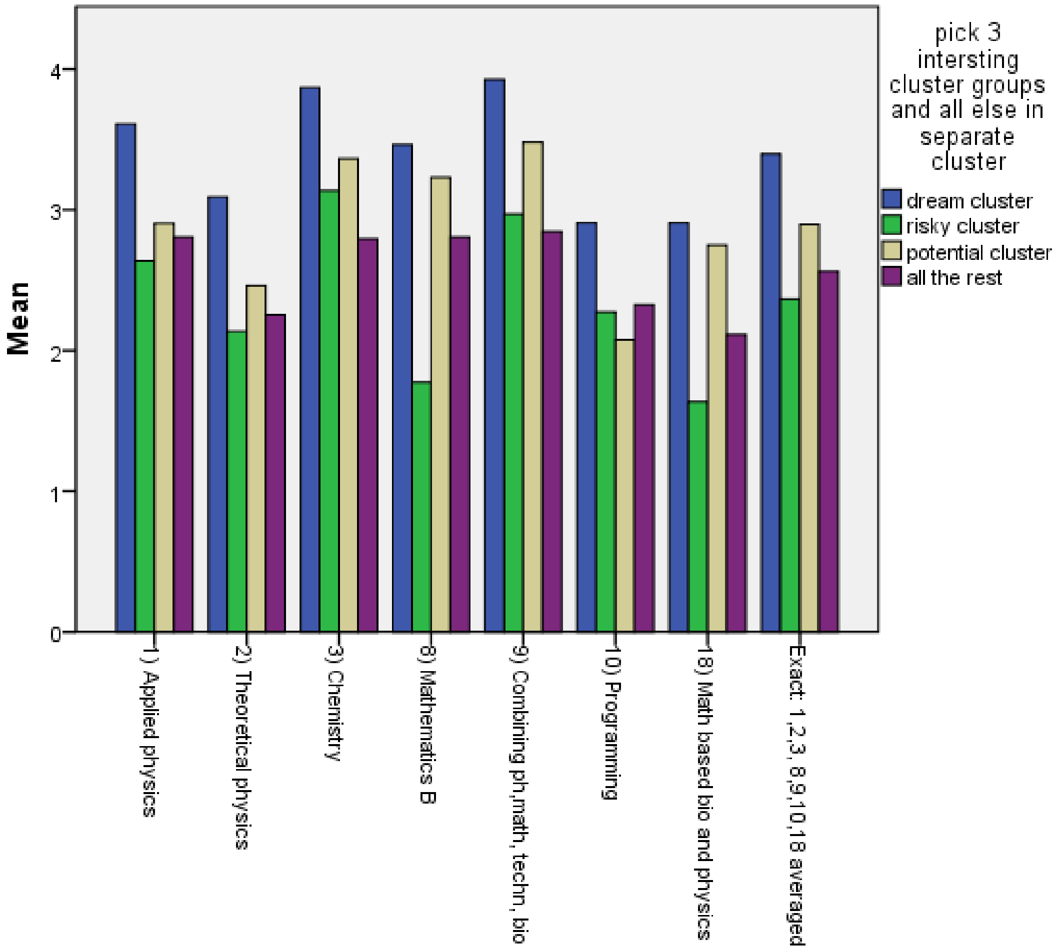
Scale	Clusters compared	N	Mean Rank	Sum of Ranks
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	risky cluster	70	86,91	6083,50
	potential cluster	56	34,24	1917,50
	Total	126		
Science/Technically oriented career average	risky cluster	69	72,62	5010,50
	potential cluster	55	49,81	2739,50
	Total	124		
Biomedical scientist career average	risky cluster	69	72,62	5010,50
	potential cluster	55	49,81	2739,50
	Total	124		
Journalist/Advisor average	risky cluster	70	73,36	5135,50
	potential cluster	56	51,17	2865,50
	Total	126		
Average MathB and Physics Grade if they have both, otherwise Mathematics B grade OR Physics grade	risky cluster	70	37,61	2632,50
	potential cluster	56	95,87	5368,50
	Total	126		
Grade Point Average of all filled in grades	risky cluster	70	37,66	2636,00
	potential cluster	56	95,80	5365,00
	Total	126		
Biology Grade OR Chemistry if no bio	risky cluster	70	47,61	3333,00
	potential cluster	56	83,36	4668,00
	Total	126		
74) Physics	risky cluster	70	45,87	3211,00
	potential cluster	56	85,54	4790,00
	Total	126		
75) Biology	risky cluster	70	60,65	4245,50
	potential cluster	56	67,06	3755,50
	Total	126		
76) Mathematics B	risky cluster	70	35,61	2493,00
	potential cluster	56	98,36	5508,00
	Total	126		

Appendix table 15: Mann Whitney test on risky cluster versus potential cluster: Significance

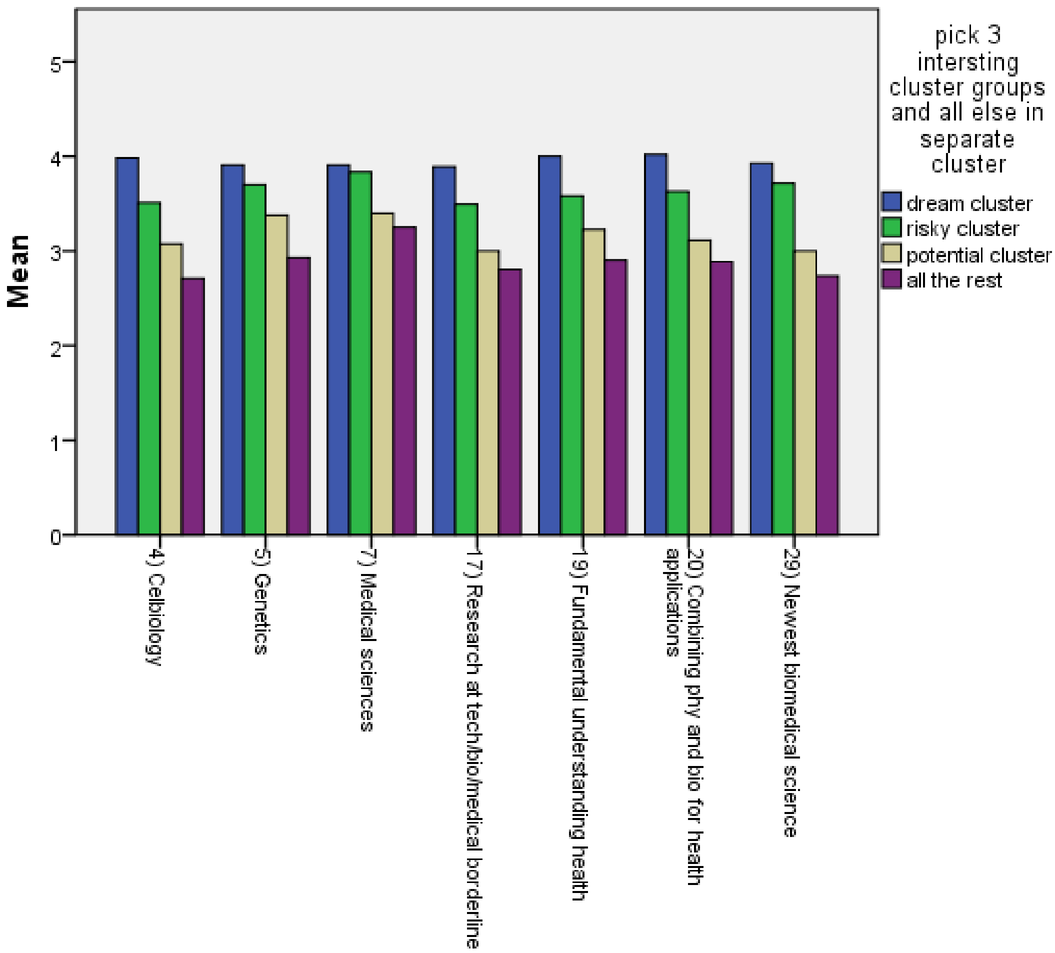
	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
BioMed: 4,5,7,17,19,20,29 averaged	1199,500	2630,500	-3,050	,002
Unf: 12,14,15,21,22,30 averaged	995,500	2321,500	-3,059	,002
Exact: 1,2,3, 8,9,10,18 averaged	1136,000	3347,000	-3,150	,002
Science: 16,23 averaged	1668,000	3264,000	-1,325	,185
Innovative: 25,26,27,28 averaged	1357,000	2897,000	-2,628	,009
International: 36,37 averaged	1775,500	3315,500	-,754	,451
Hand calculated average score core attraction of program 39+40+42	1092,500	2688,500	-4,325	,000
Hand calculated average score broadness program 41+43+45	781,000	2377,000	-5,873	,000
Hand calculated average score job evaluation 60-62	487,500	2083,500	-7,294	,000

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Hand calculated average score all scaled items 39,40,41,42,43,45,60-62	321,500	1917,500	-8,061	,000
Science/Technically oriented career average	1199,500	2739,500	-3,523	,000
Biomedical scientist career average	1199,500	2739,500	-3,523	,000
Journalist/Advisor average	1269,500	2865,500	-3,435	,001
Average MathB and Physics Grade if they have both, otherwise Mathematics B grade OR Physics grade	147,500	2632,500	-8,917	,000
Grade Point Average of all filled in grades	151,000	2636,000	-8,886	,000
Biology Grade OR Chemistry if no bio	848,000	3333,000	-5,515	,000
74) Physics	726,000	3211,000	-6,393	,000
75) Biology	1760,500	4245,500	-1,080	,280
76) Mathematics B	8,000	2493,000	-9,858	,000

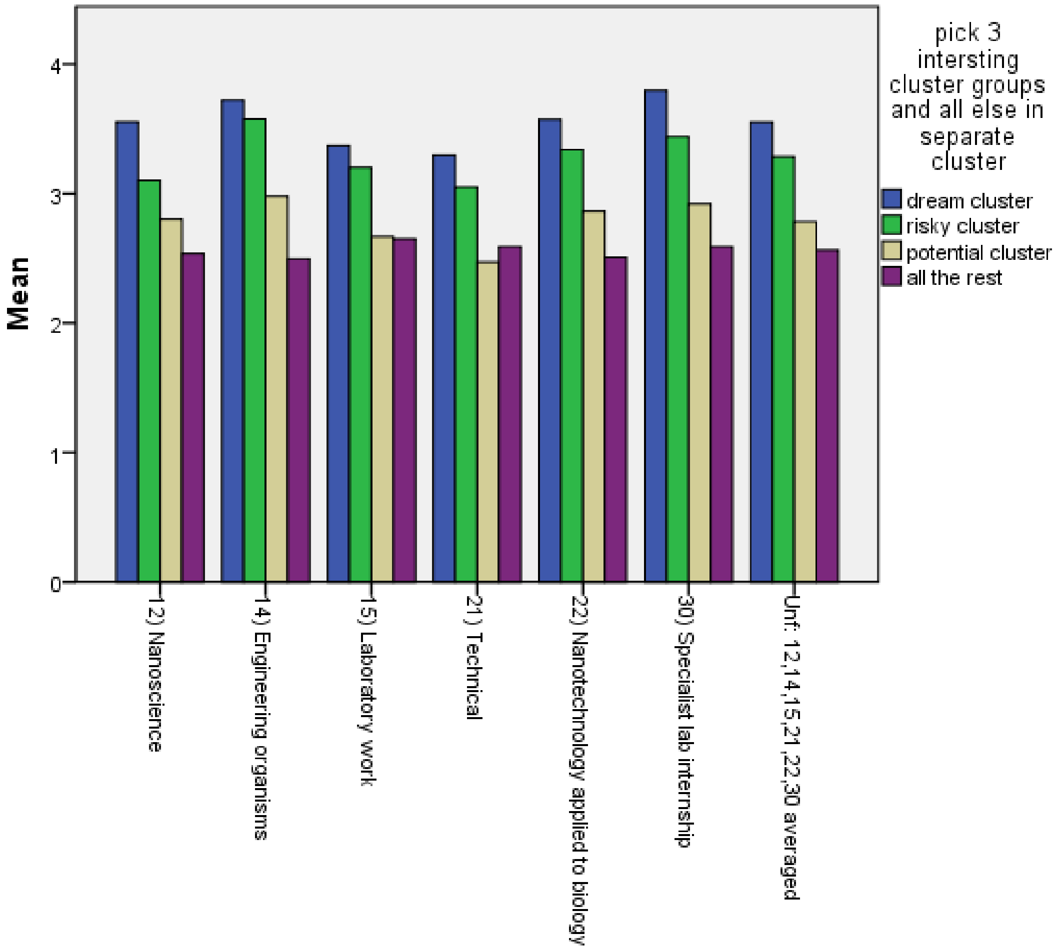
Appendix 20 Single item mean scores per scale and per cluster



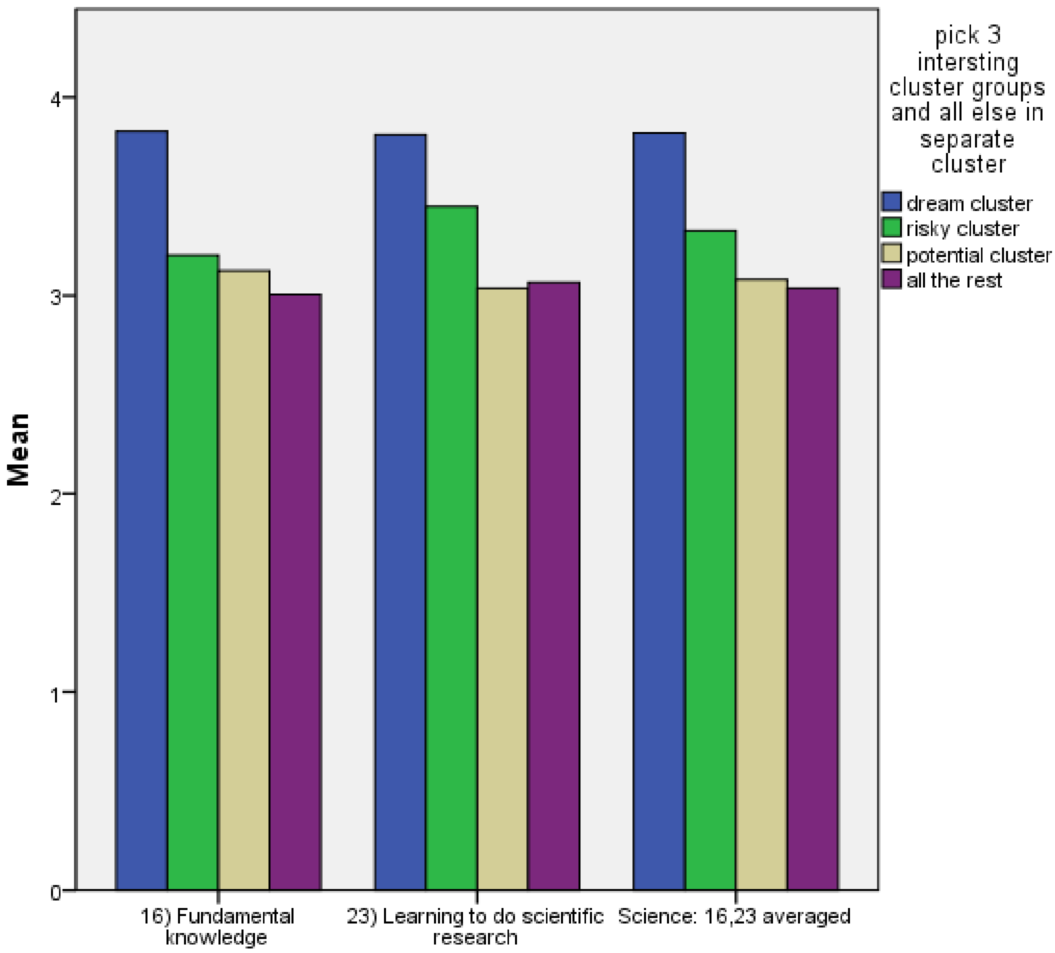
Appendix figure 2: Single item scores for Exact/STEM related scale



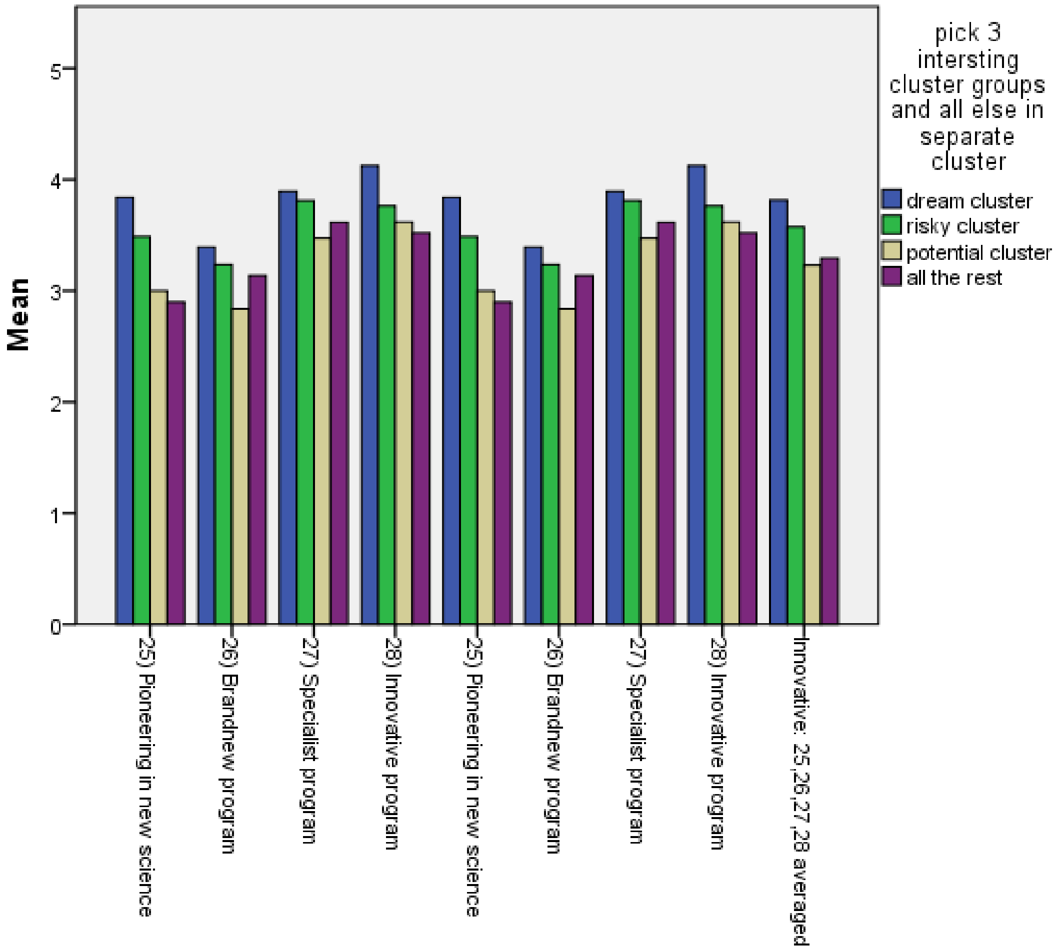
Appendix figure 3: Single item scores for Biomedical scale



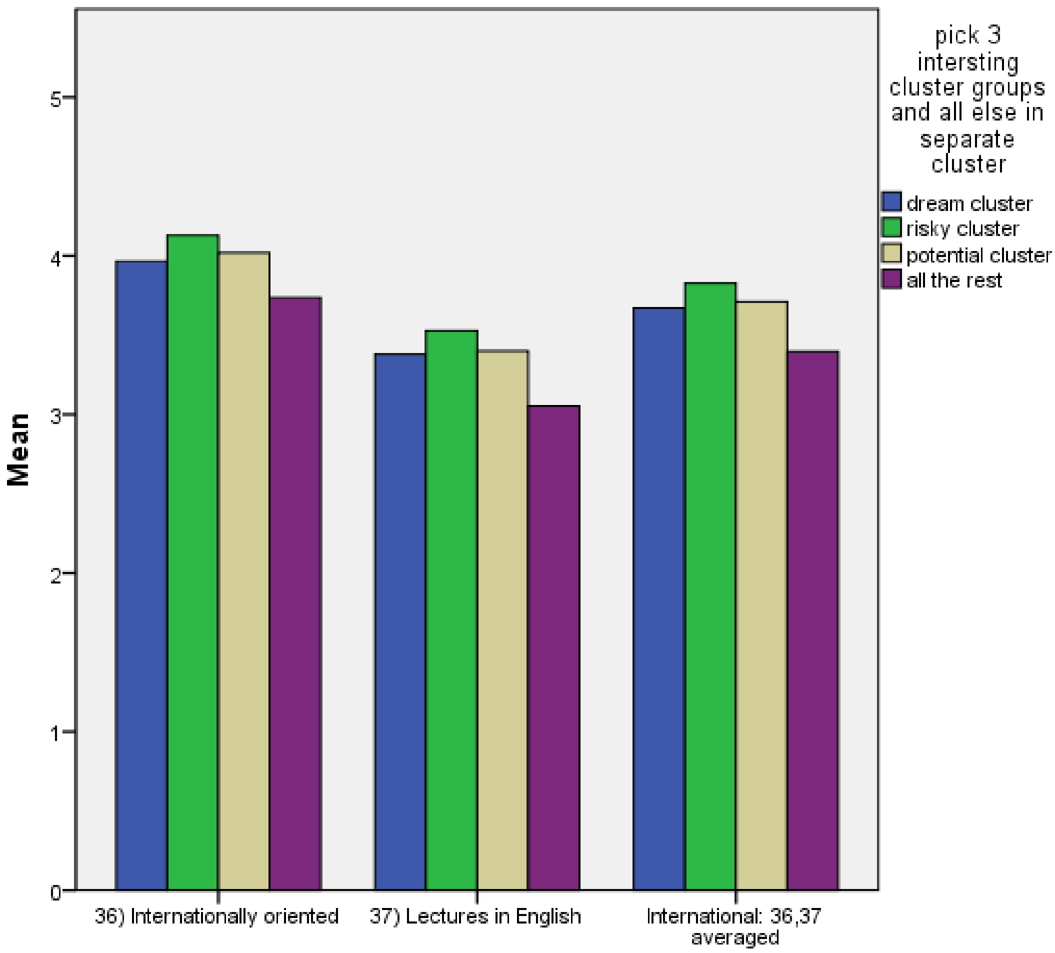
Appendix figure 4: Single item scores for Unfamiliar scale



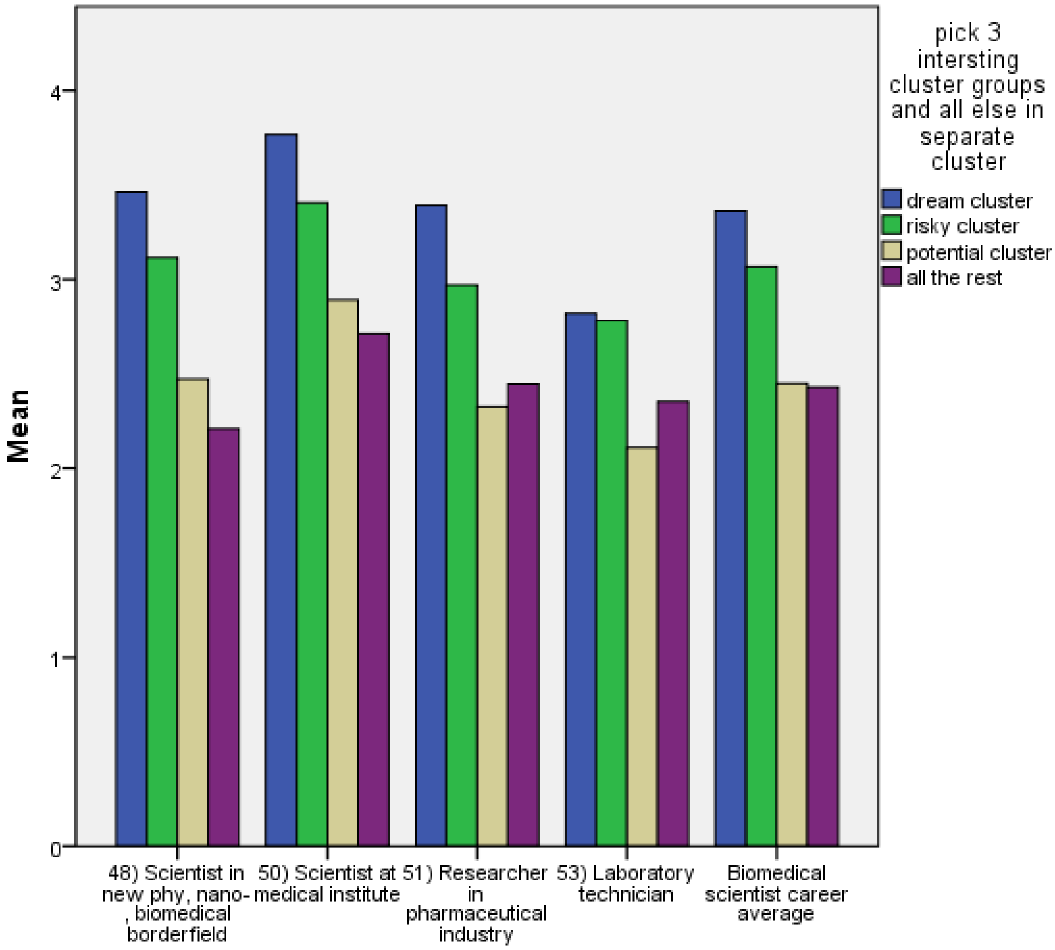
Appendix figure 5: Single item scores for Fundamental Science scale



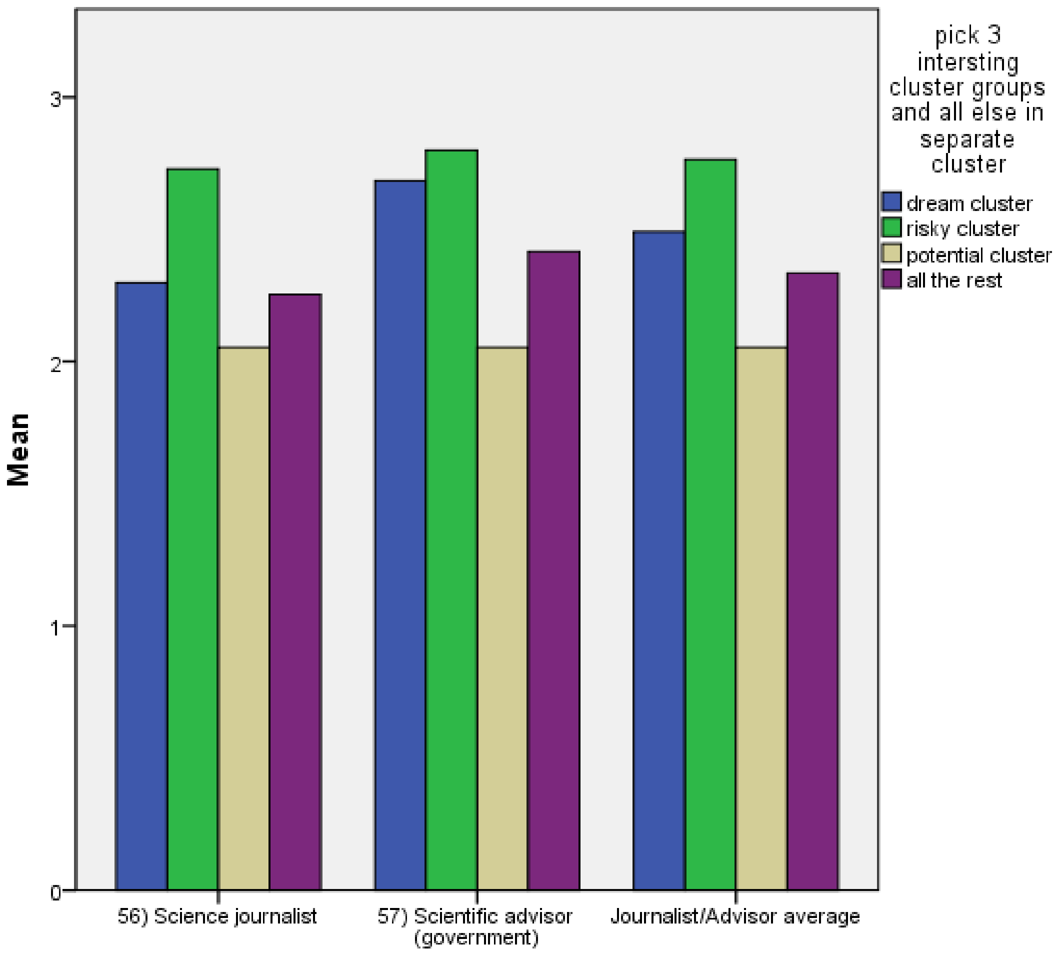
Appendix figure 6: Single item scores for Innovative/specialist scale



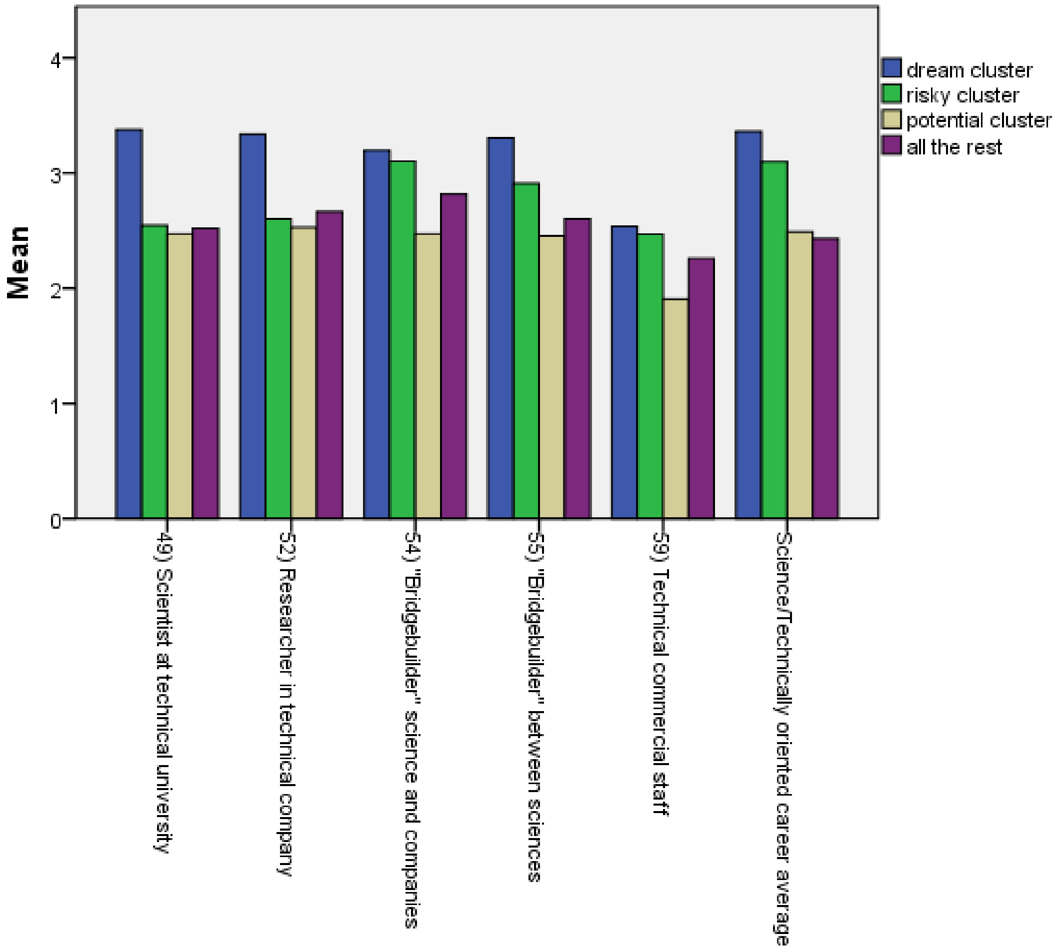
Appendix figure 7: Single item scores for International scale



Appendix figure 8: Single item scores for Biomedical scientist career scale

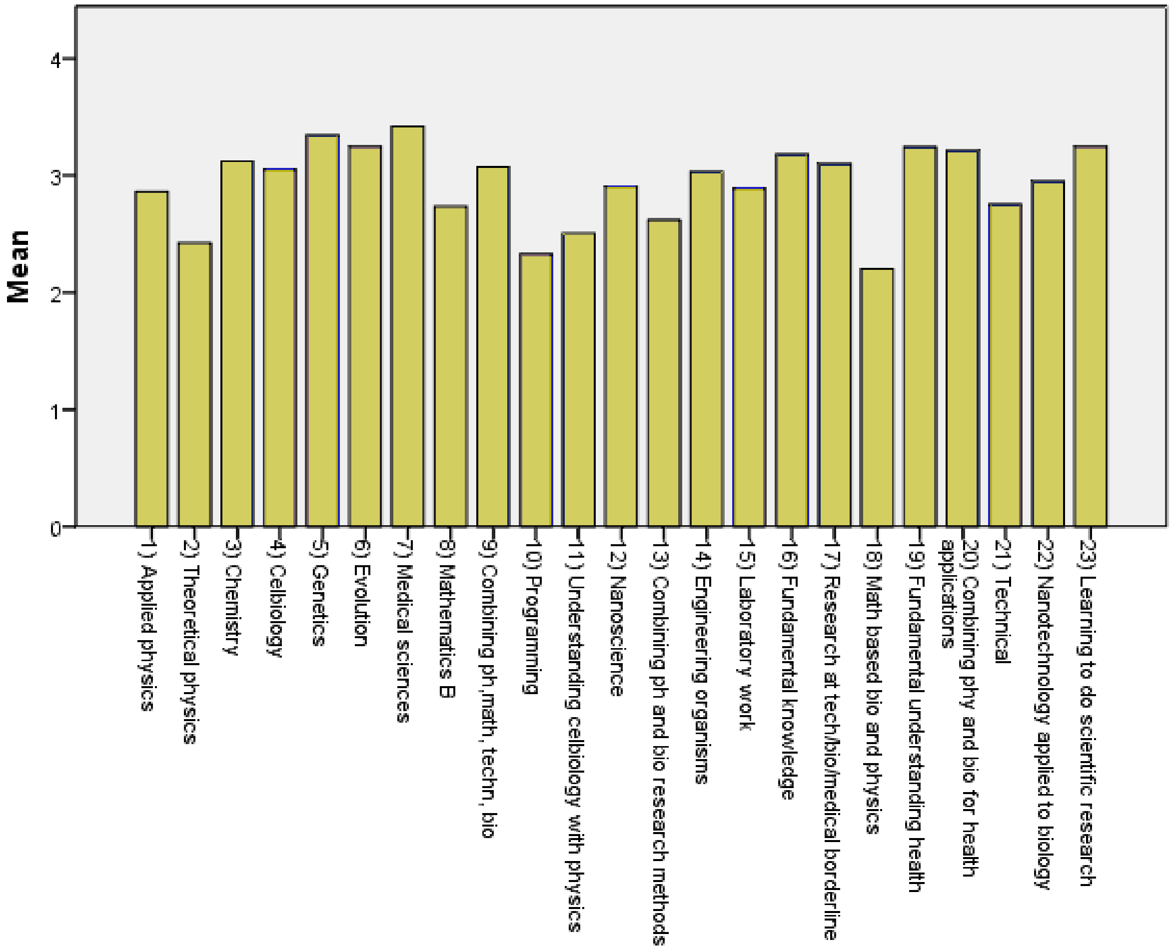


Appendix figure 9: Single item scores for Alpha direction career scale

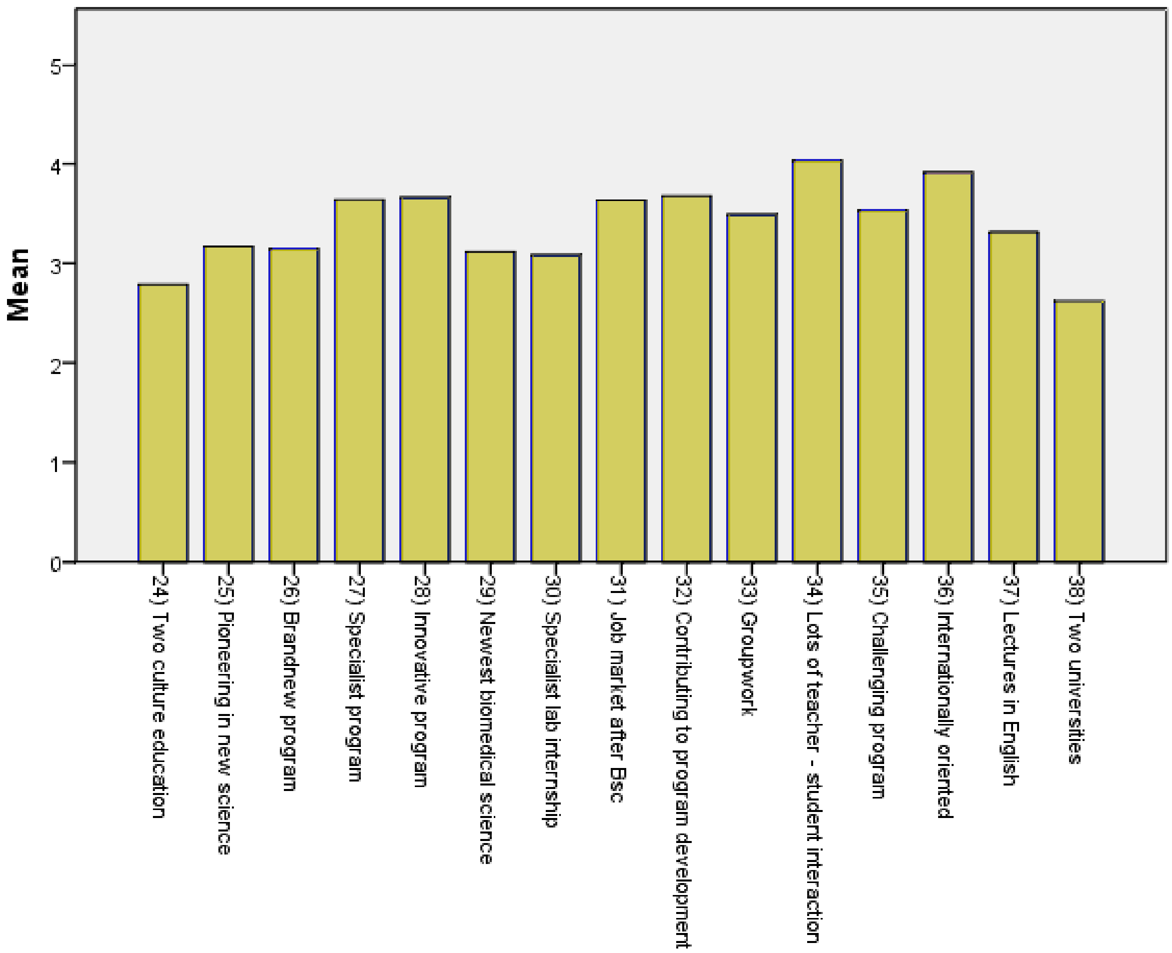


Appendix figure 10: Single item scores for Scientific/Technically oriented career scale

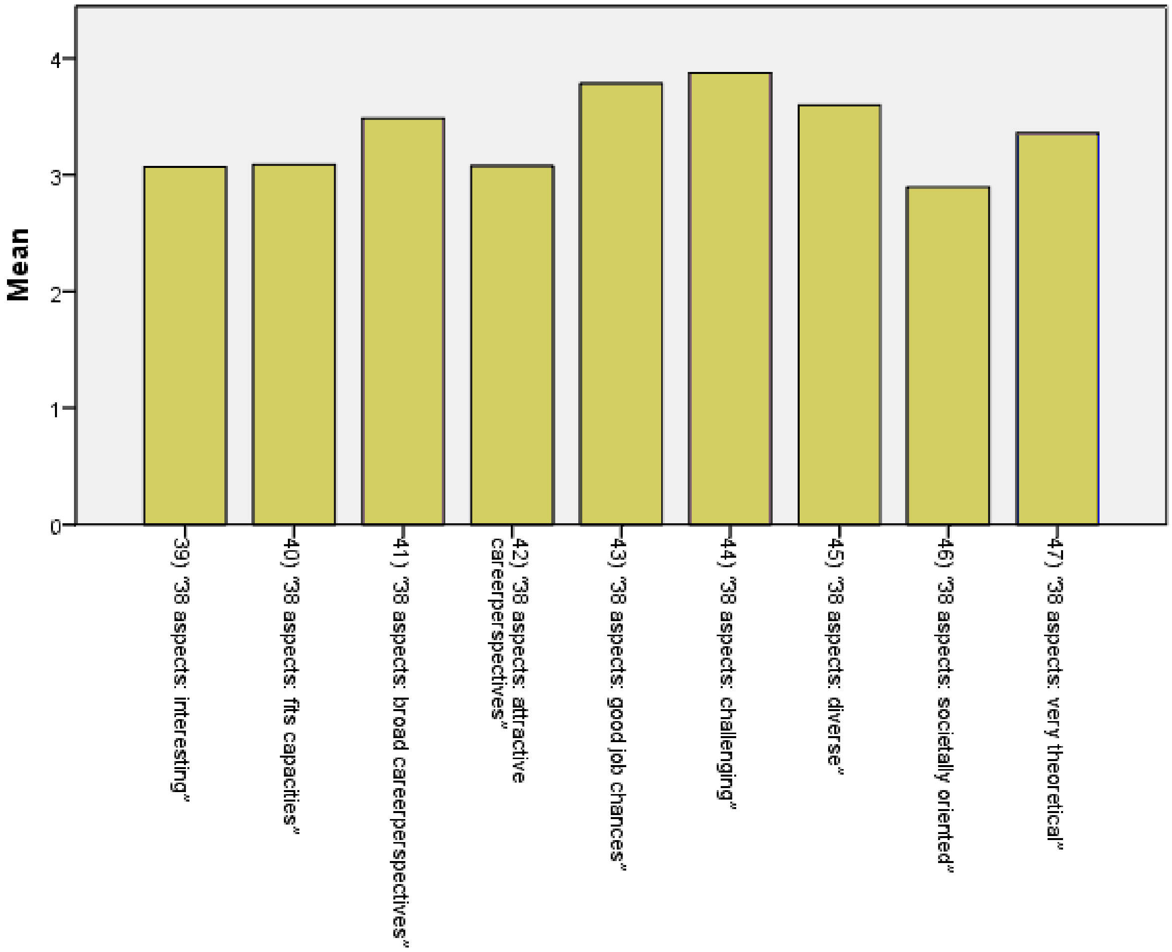
Appendix 21 Mean scores of questionnaire items 1-38, averaged over all respondents



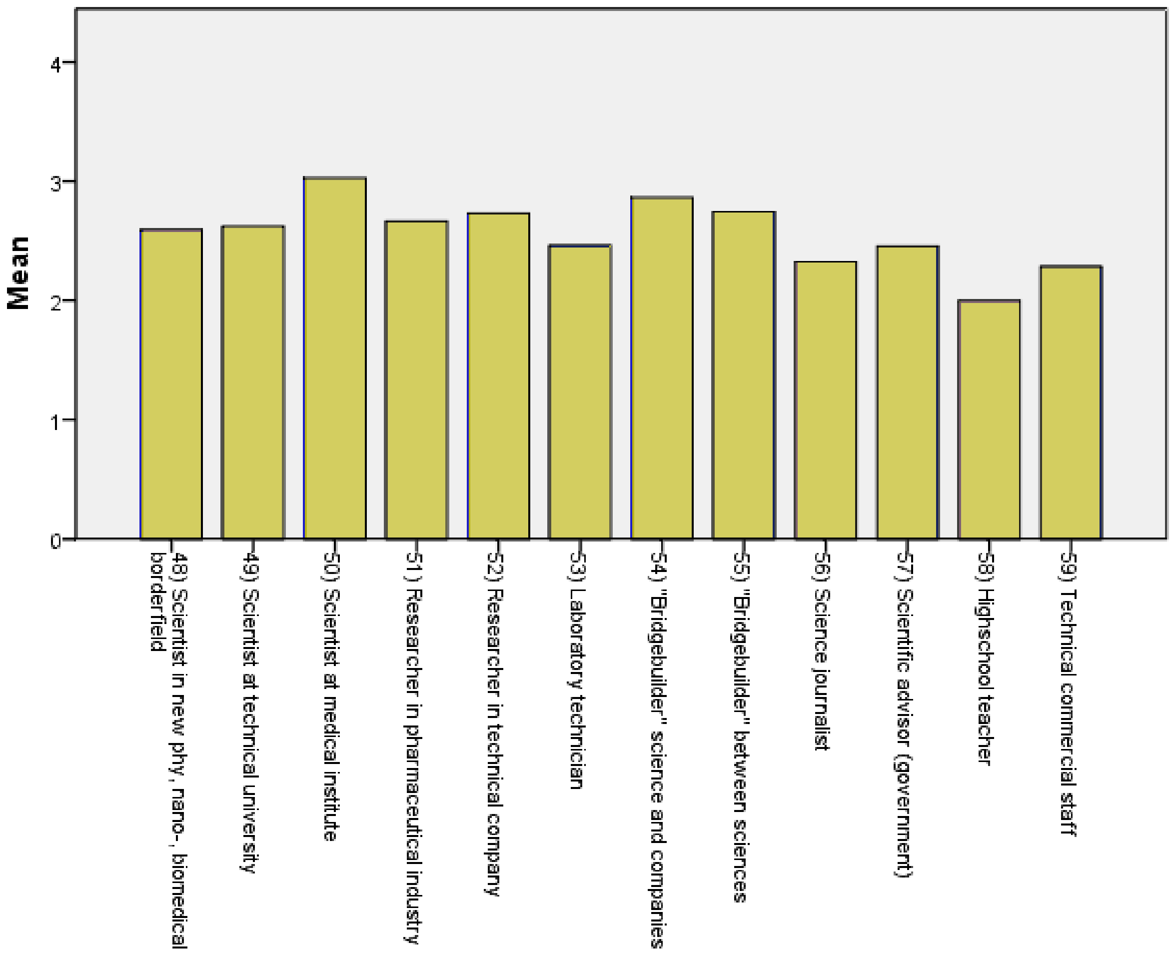
Appendix figure 11: Single item scores and scores of metric background questions 1-23 averaged over the entire valid respondent population



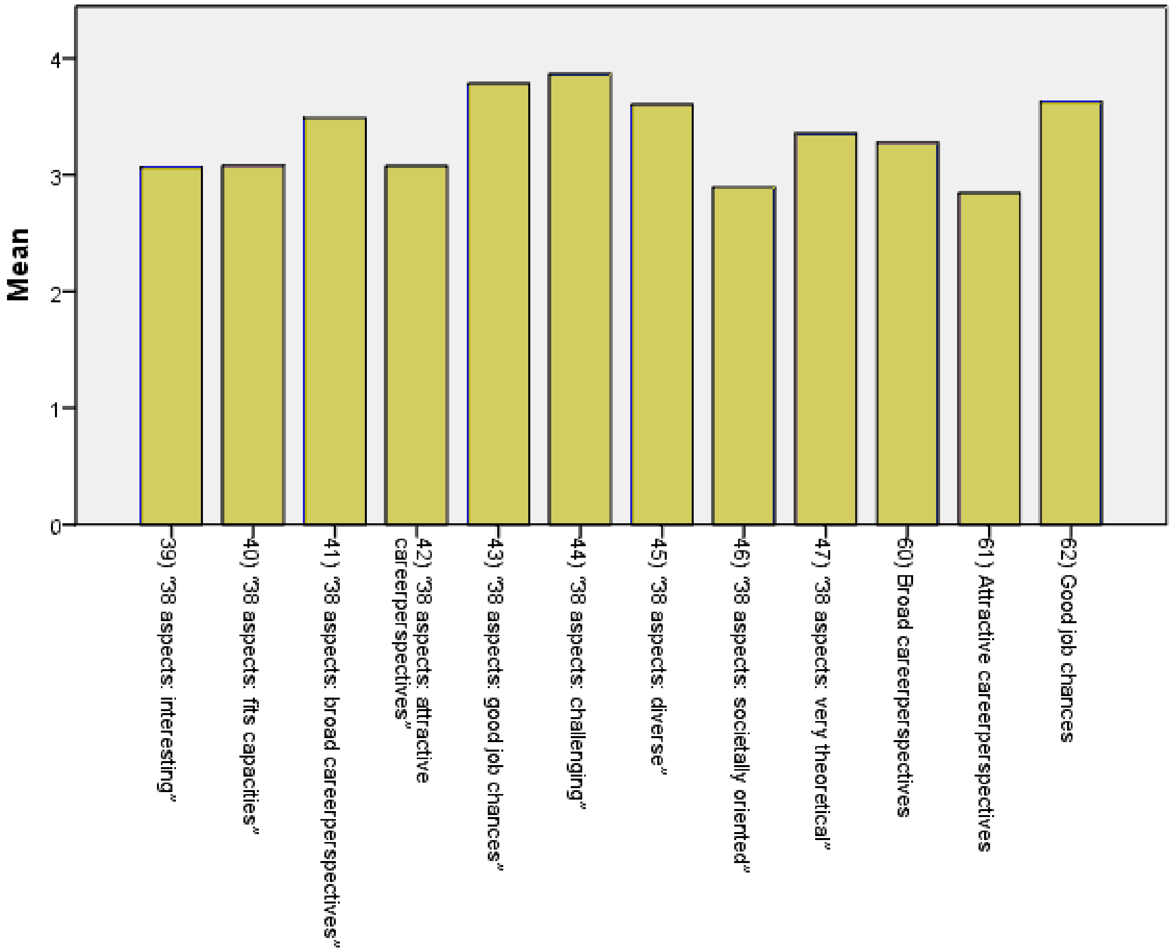
Appendix figure 12: Single item scores and scores of metric background questions 24-38 averaged over the entire valid respondent population



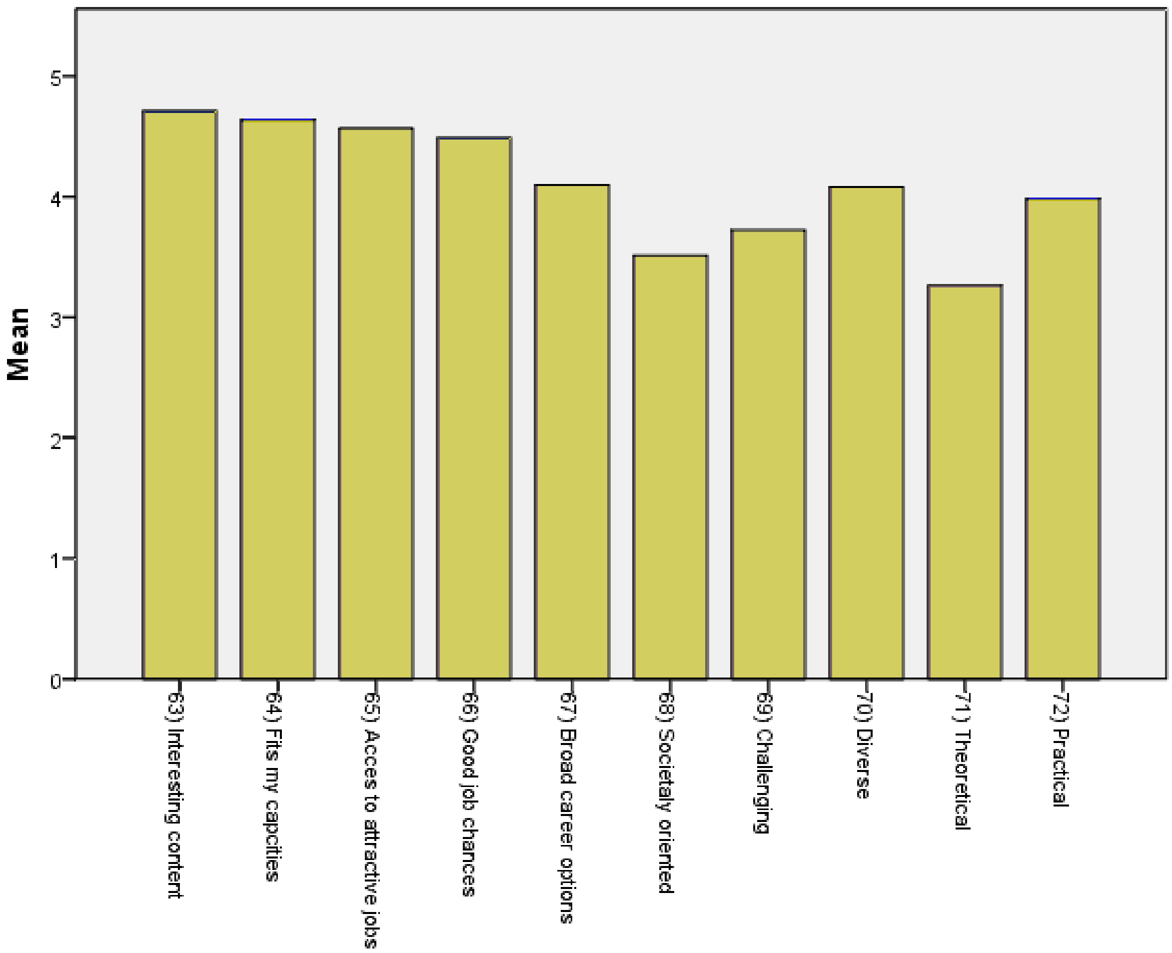
Appendix figure 13: Single item scores and scores of metric background questions 39-47 averaged over the entire valid respondent population



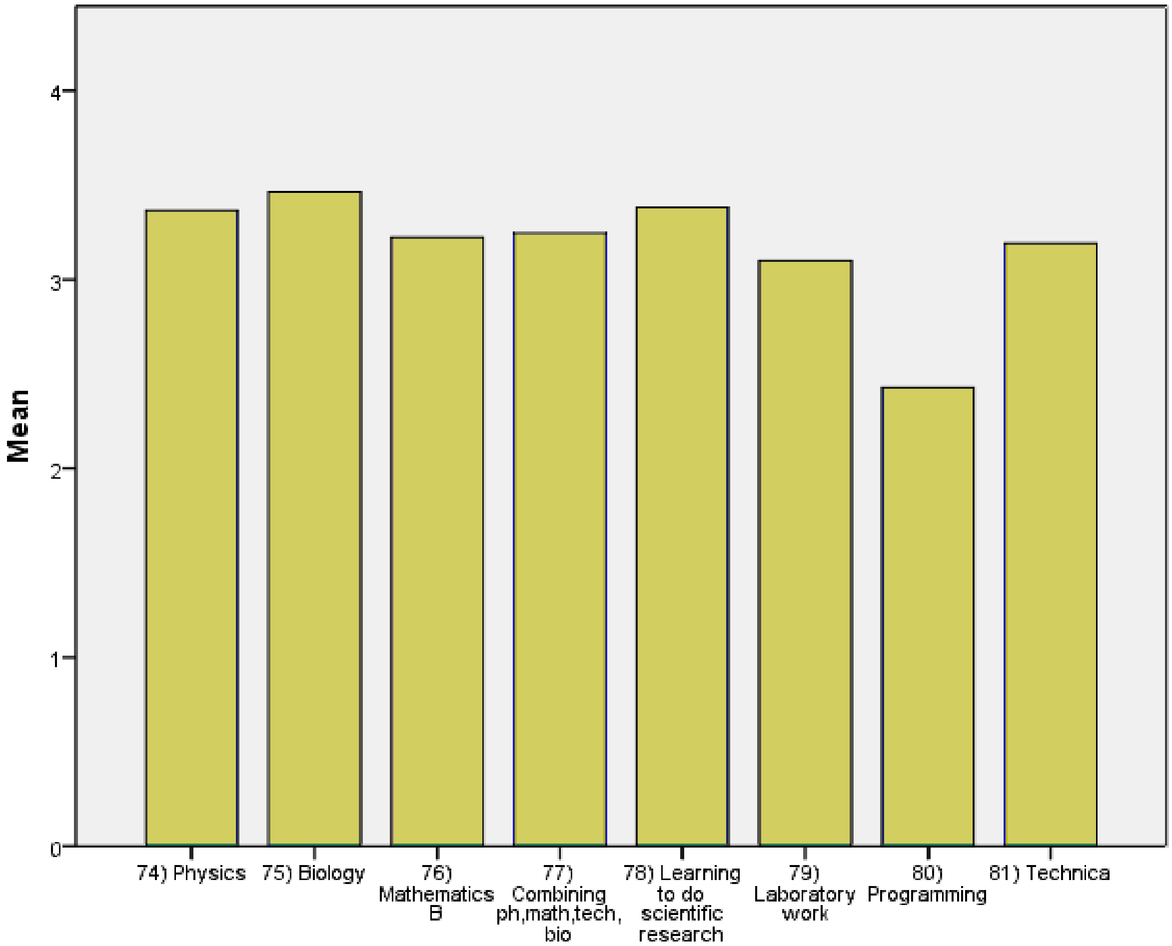
Appendix figure 14: Single item scores and scores of metric background questions 48-59 averaged over the entire valid respondent population



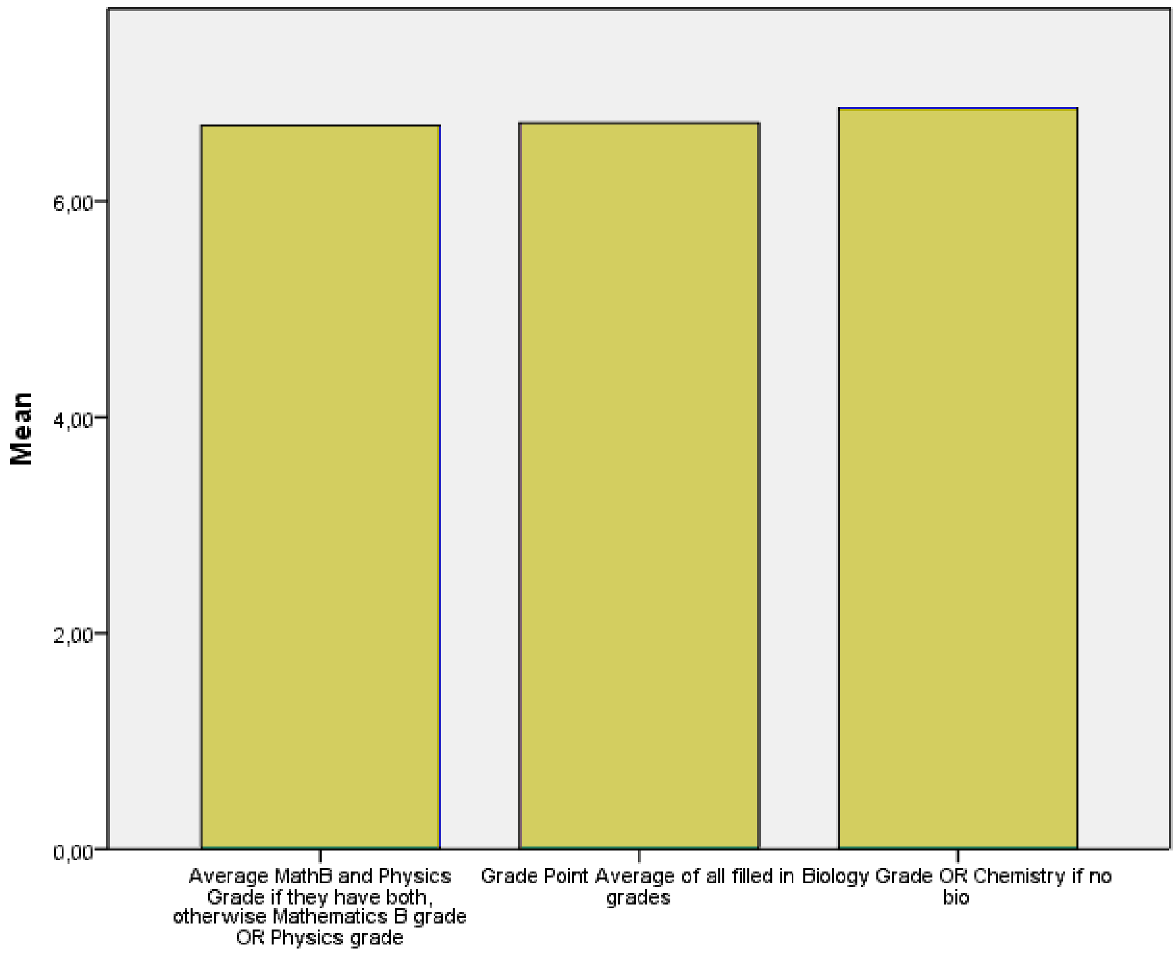
Appendix figure 15: Single item scores and scores of metric background questions 39 – 62 averaged over the entire valid respondent population



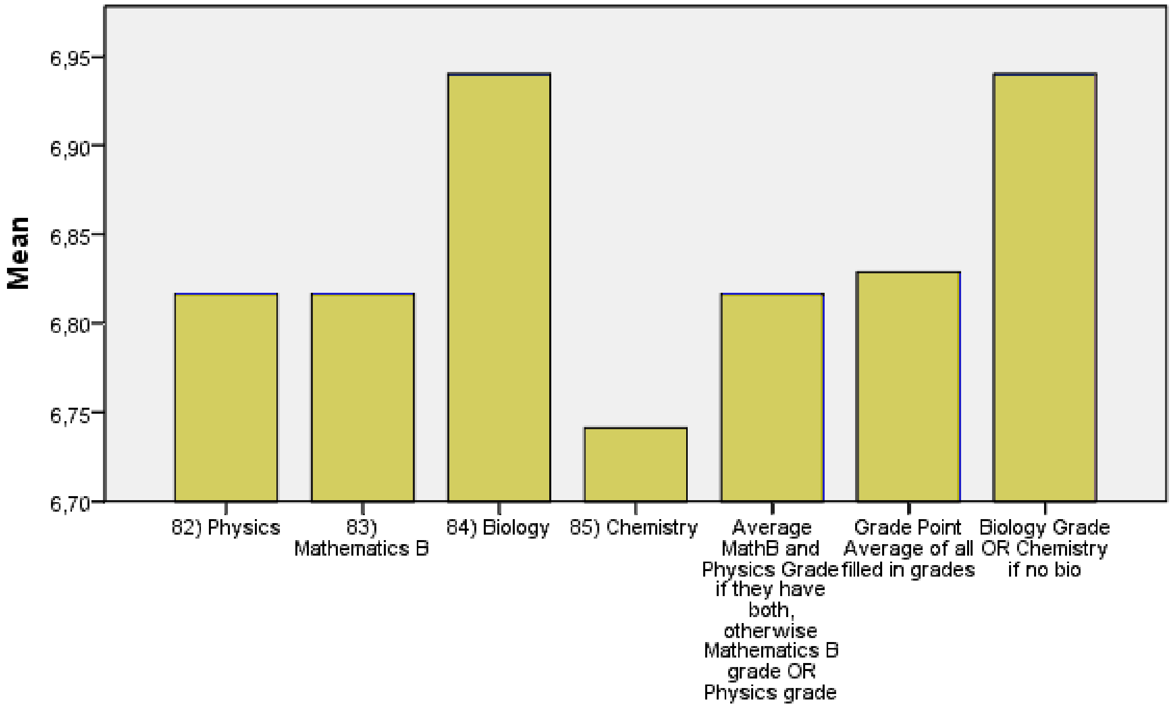
Appendix figure 16: Single item scores and scores of metric background questions 63-72 averaged over the entire valid respondent population



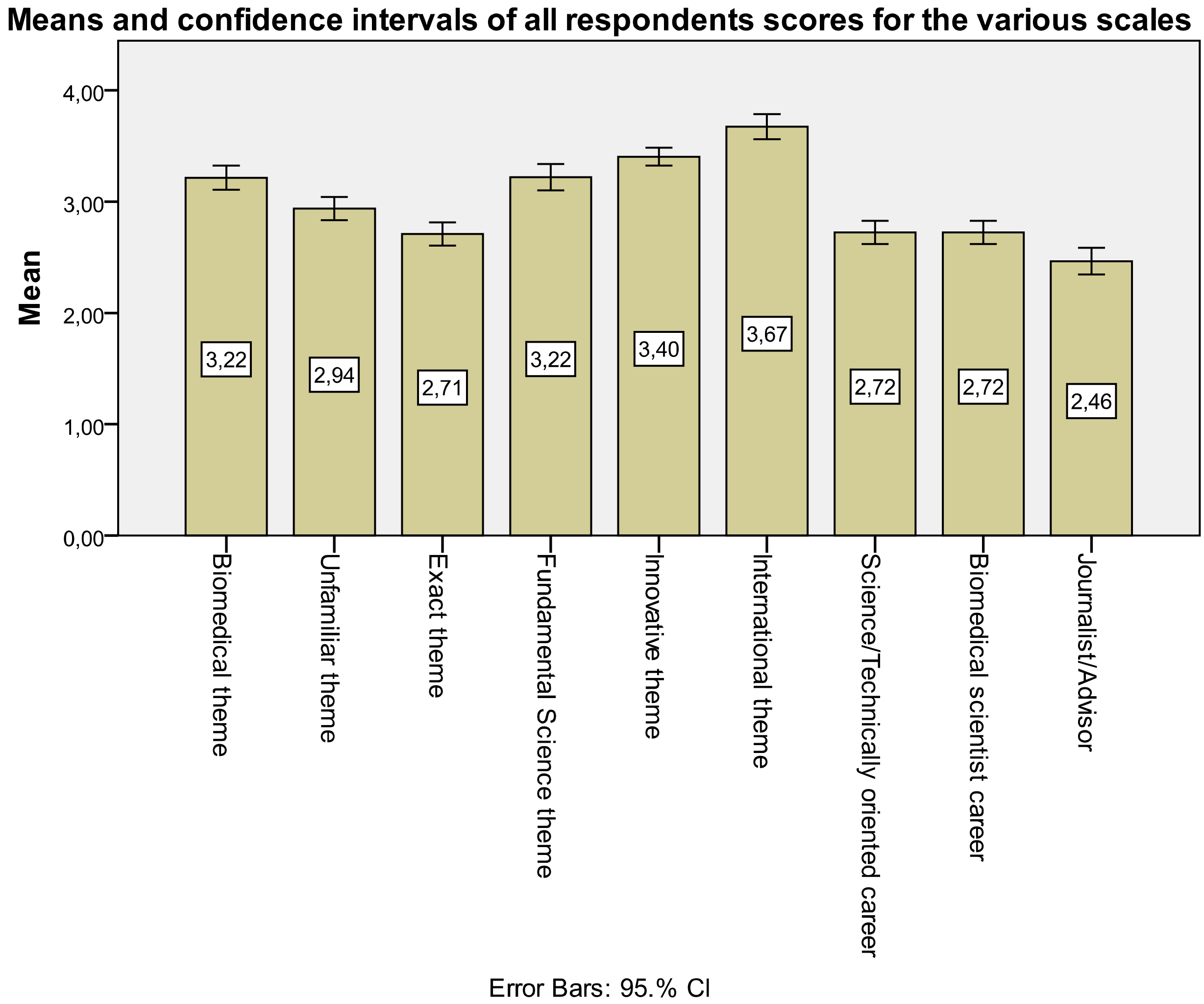
Appendix figure 17: Single item scores and scores of metric background questions 74-81 averaged over the entire valid respondent population



Appendix figure 18: (Combined) GPA's averaged over the entire valid respondent population



Appendix figure 19: (Combined) GPA's averaged over the entire valid respondent population



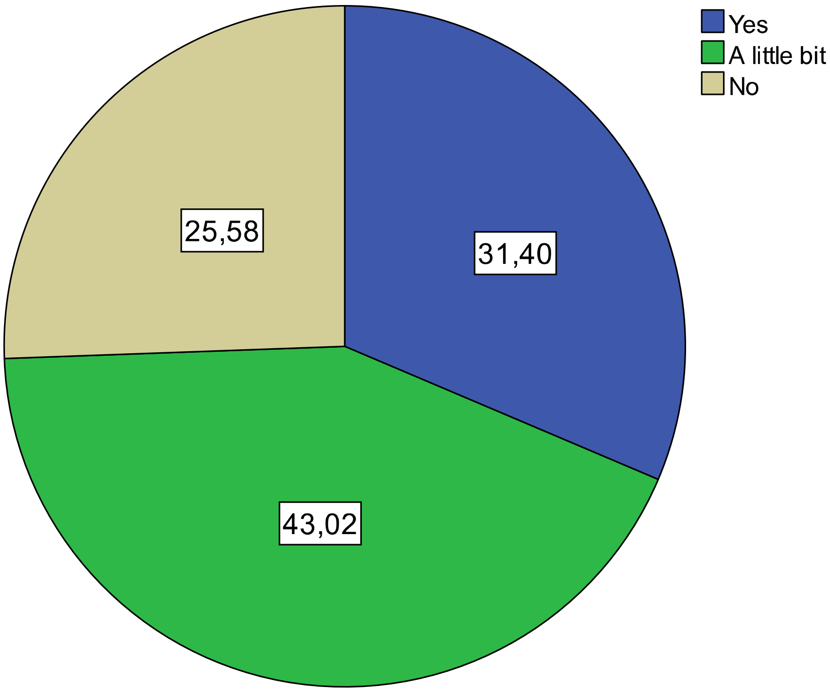
Appendix figure 20: Scale scores "Content and career aspects" averaged over the entire valid respondent population

Appendix 22 Higher Education Decision all respondents

Statistics: ***Have you allready decided what (kind of) post-compulsary education you want to follow?***

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ja	135	30,7	31,4	31,4
	Een beetje	185	42,0	43,0	74,4
	Nee	110	25,0	25,6	100,0
	Total	430	97,7	100,0	
Missing	9999	8	1,8		
	System	2	,5		
	Total	10	2,3		
Total		440	100,0		

Have you already decided what (kind of) post-compulsary education you want to follow?



Appendix 23 List of High schools and respondents

** Testers completed the questionnaire out loud and are not counted as respondents*

Name of School	Type	Location	Number of respondents and testers*	Physics or Chemistry lesson
Christelijk Lyceum Delft	Technasium	Delft	20	Physics
Christelijk Lyceum Delft	Technasium	Delft	23	Physics
Fioretti College	Gymnasium & Atheneum	Lisse	16	Chemistry
Fioretti College	Gymnasium & Atheneum	Lisse	18 + tester*	Chemistry
Sint Laurenscollege Atheneum en Havo	Atheneum	Rotterdam	13	Physics
St. Bonifatius College Utrecht	Gymnasium & Atheneum	Utrecht	18+1 tester *	Chemistry
St. Bonifatius College Utrecht	Gymnasium & Atheneum	Utrecht	21+1 tester *	Chemistry
Scholengemeenschap St Bonifatius College	?	Utrecht	14	Chemistry
Scholengemeenschap St Bonifatius College	?	Utrecht	15	Chemistry
Penta College voor Christelijk Vo Lyc Ha	?	Hellevoetsluis	20 + 22	Chemistry
Christelijke Scholengemeenschap Calvijn	Gymnasium & Atheneum	Rotterdam	34	Chemistry
Stedelijk Dalton Lyceum	Dalton Lyceum	Dordrecht	18 + 1 tester *	Chemistry
Stedelijk Dalton Lyceum	Dalton Lyceum	Dordrecht	23 + 1 tester *	Chemistry
Stedelijk Gymnasium Leiden	Gymnasium	Leiden	15 (*+7 single profiles that were not included for practical reasons and reasons of abundance*)	Chemistry

Name of School	Type	Location	Number of respondents and testers*	Physics or Chemistry lesson
Stedelijk Gymnasium Leiden	Gymnasium	Leiden	21	Chemistry
Erasmus college zoetermeer	Dalton	Zoetermeer	12	Chemistry
Atheneum College Hageveld	Atheneum	Heemstede	27 (2 classes, same teacher)	Chemistry
Atheneum College Hageveld	Atheneum	Heemstede	38 (2 classes, same teacher)	Chemistry
Het Rijnlands Lyceum Scholengemeenschap	?	Wassenaar	17+1 tester *	Physics
Het Rijnlands Lyceum Scholengemeenschap	?	Wassenaar	12+1 tester *	Physics
Edith Stein College	Atheneum	Den Haag	8	Chemistry
Bonaventuracollege Scholengemeenschap voor Gymnasium, Atheneum and Havo	Atheneum & Gymnasium	Leiden	25 + 13 *(+5 single profiles that were not included for practical reasons and reasons of abundance).*	Chemistry

Appendix 24 Final Questionnaire 5 VWO

Beste 5VWO'er met een NT/NG profiel. Alvast heel erg bedankt voor het invullen van deze enquête! Er zijn, na deze introductie, vier pagina's en invullen ervan duurt ongeveer 9 minuten. Misschien weet je voor sommige vragen niet direct het antwoord, probeer toch om alle vragen vlot in te vullen en te vertrouwen op je eerste ingeving. Als je een foutje maakt bij het invullen omcirkel dan je uiteindelijke antwoord! Gegevens worden anoniem verwerkt en de resultaten worden gebruikt om voorlichting over een nieuwe bachelor opleiding van de universiteit te verbeteren.

Veel plezier met invullen!

Waar doet het woord **NANOBIOLOGIE** je aan denken? Vertel het in één of twee zinnen.		……………………………………………………………………… ………………………………………………………………………
Heb je hier een positief of een negatief gevoel bij?	☐ **Positief** ☐ **Negatief**	Leg kort uit. ……………………………………………………………………… ………………………………………………………………………

Inhoudelijke opleidingskenmerken
Hieronder volgen een aantal onderwerpen. Kruis per onderwerp aan in hoeverre het je **aanspreekt**. Vul je eerste ingeving in. (*Wanneer een onderwerp je echt helemaal niets zegt kun je dat ook aankruisen.*)

Stelling: "dit spreekt mij aan"	1 Helemaal mee **on**eens	2 Een beetje mee **on**eens	3 Neutraal	4 Een beetje mee eens	5 Helemaal mee eens	*Dit zegt me echt helemaal niets*
1) Technische/toegepaste Natuurkunde	☐	☐	☐	☐	☐	☐
2) Theoretische Natuurkunde	☐	☐	☐	☐	☐	☐
3) Scheikunde	☐	☐	☐	☐	☐	☐
4) Celbiologie (bouw en werking van levende cellen op moleculair niveau: DNA, eiwitten etc)	☐	☐	☐	☐	☐	☐
5) Genetica	☐	☐	☐	☐	☐	☐
6) Evolutie	☐	☐	☐	☐	☐	☐
7) Medische wetenschap	☐	☐	☐	☐	☐	☐
8) Wiskunde B	☐	☐	☐	☐	☐	☐
9) Natuurkunde, wiskunde, techniek en biologie combineren	☐	☐	☐	☐	☐	☐
10) Programmeren: een wiskundig model bouwen van een levend organisme met de computer	☐	☐	☐	☐	☐	☐
11) De complexe biologische levensprocessen in cellen met behulp van natuurkunde begrijpen	☐	☐	☐	☐	☐	☐
12) Nanowetenschap	☐	☐	☐	☐	☐	☐
13) Onderzoeksmethoden van de natuurkundige en biologische wetenschappen leren combineren	☐	☐	☐	☐	☐	☐
14) Sleutelen aan levende organismen op moleculaire schaal om ze te verbeteren	☐	☐	☐	☐	☐	☐
15) Laboratoriumwerk	☐	☐	☐	☐	☐	☐
16) Fundamentele kennis: dingen tot op de bodem uitzoeken	☐	☐	☐	☐	☐	☐
17) Onderzoek op het grensvlak van techniek, biologie en medische wetenschap	☐	☐	☐	☐	☐	☐
18)Wetenschappelijke biologie en natuurkunde vakken op basis van complexe wiskunde	☐	☐	☐	☐	☐	☐
19) Grondig begrijpen hoe gezondheid en ziekte werken op het niveau van moleculen	☐	☐	☐	☐	☐	☐
20) Natuurkunde en biologie combineren en medisch toepassen (bijv: nieuwe medicijnen)	☐	☐	☐	☐	☐	☐
21) Techniek: werken met en begrijpen van apparaten (zoals specialistische microscopen)	☐	☐	☐	☐	☐	☐
22) Nanotechnologie toepassen in biologie op celniveau om te onderzoeken hoe 'leven' werkt	☐	☐	☐	☐	☐	☐
23) Goed wetenschappelijk onderzoek leren doen	☐	☐	☐	☐	☐	☐

Andere opleidingskenmerken Hieronder volgen een aantal andere opleidingskenmerken. Kruis per kenmerk aan in hoeverre je het eens bent met de stelling: **“dit spreek mij aan”**.					
Stelling: “dit spreek mij aan”	1 Helemaal mee **on**eens	2 Een beetje mee **on**eens	3 Neutraal	4 Een beetje mee eens	5 Helemaal mee eens
24) Opgeleid worden in de twee ‘culturen’ van techneuten enerzijds en medische wetenschappers anderzijds	☐	☐	☐	☐	☐
25) Pionieren in een nieuw onderzoeksveld: opgeleid worden tot een nieuw type wetenschap-per (met een uniek pakket kennis en vaardigheid)	☐	☐	☐	☐	☐
26) Gloednieuwe opleiding	☐	☐	☐	☐	☐
27) Specialistische opleiding	☐	☐	☐	☐	☐
28) Innovatieve opleiding	☐	☐	☐	☐	☐
29) Bijdragen aan de nieuwste ontwikkelingen in de biomedische wetenschap	☐	☐	☐	☐	☐
30) Specialisatiestage naar keuze in een geavanceerd onderzoekslaboratorium in het derde jaar	☐	☐	☐	☐	☐
31) Mogelijkheid om met je bachelor-diploma de arbeidsmarkt op te kunnen gaan.	☐	☐	☐	☐	☐
32) Inspraak in de inrichting van de opleiding	☐	☐	☐	☐	☐
33) Veel werken in groepjes	☐	☐	☐	☐	☐
34) Veel interactie tussen docenten en studenten	☐	☐	☐	☐	☐
35) Uitdagende studie die veel inzet vraagt	☐	☐	☐	☐	☐
36) Internationaal gericht	☐	☐	☐	☐	☐
37) College in het Engels	☐	☐	☐	☐	☐
38) College aan twee universiteiten (Delft en Erasmus Rotterdam)	☐	☐	☐	☐	☐
Samenvattend over alle bovenstaande kenmerken (1 t/m 38). Kruis aan in hoeverre je het eens bent met de volgende stellingen:					
39) “Een opleiding met deze 38 kenmerken vind *ik* inhoudelijk interessant.”	☐	☐	☐	☐	☐
40) “Een opleiding met deze 38 kenmerken is past bij wat *ik* kan.”	☐	☐	☐	☐	☐
41) “Een opleiding met deze 38 kenmerken biedt *mij* een breed beroepsperspectief.”	☐	☐	☐	☐	☐
42) “Een opleiding met deze 38 kenmerken biedt *mij* een aantrekkelijk beroepsperspectief.”	☐	☐	☐	☐	☐
43) “Een opleiding met deze 38 kenmerken biedt je in het algemeen een goede kans op een baan.”	☐	☐	☐	☐	☐
44) “Een opleiding met deze 38 kenmerken vind *ik* moeilijk/uitdagend.”	☐	☐	☐	☐	☐
45) “Een opleiding met deze 38 kenmerken vind *ik* veelzijdig.”	☐	☐	☐	☐	☐
46) “Een opleiding met deze 38 kenmerken vind *ik* maatschappelijk gericht.”	☐	☐	☐	☐	☐
47) “Een opleiding met deze 38 kenmerken vind *ik* erg theoretisch.”	☐	☐	☐	☐	☐

Mogelijke toekomstige beroepen
Hieronder volgen een aantal soorten beroepen die je na afronding van de studie Nanobiologie zou kunnen uitoefenen. Kruis per beroepssoort aan in hoeverre je het eens bent met de stelling: **“ik vind dit beroep aantrekkelijk”**

Stelling: “ik vind dit beroep aantrekkelijk”	1 Helemaal mee **on**eens	2 Een beetje mee **on**eens	3 Neutraal	4 Een beetje mee eens	5 Helemaal mee eens
48) Wetenschapper in nieuw veld op grensvlak natuurkunde, nano- en biomedische wetenschap	☐	☐	☐	☐	☐
49) Wetenschapper aan een technische universiteit	☐	☐	☐	☐	☐
50) Wetenschapper aan een medische instelling: bijvoorbeeld ontwikkeling nieuwe medicijnen	☐	☐	☐	☐	☐
51Onderzoeker in de pharmaceutische industrie	☐	☐	☐	☐	☐
52) Onderzoeker in een technisch bedrijf	☐	☐	☐	☐	☐
53) Laboratorium medewerker. (Analist)	☐	☐	☐	☐	☐
54) Een “bruggenbouwer” tussen wetenschap en bedrijven	☐	☐	☐	☐	☐
55) Een “bruggenbouwer” tussen verschillende wetenschappen	☐	☐	☐	☐	☐
56) Wetenschapsjournalist	☐	☐	☐	☐	☐
57) Wetenschapsadviseur (bvb. bij de overheid)	☐	☐	☐	☐	☐
58) Docent op een middelbare school	☐	☐	☐	☐	☐
59) Technisch commercieel medewerker in een bedrijf dat apparaten verkoopt aan instellingen in de life sciences	☐	☐	☐	☐	☐

Samenvattend: In hoeverre ben je het eens met de volgende stellingen? Kruis je antwoord aan.

60) “Een opleiding voor bovenstaande beroepen biedt mij een breed beroepsperspectief.”	☐	☐	☐	☐	☐
61) “Een opleiding voor bovenstaande beroepen biedt mij een aantrekkelijk beroepsperspectief.”	☐	☐	☐	☐	☐
62) “Een opleiding voor bovenstaande beroepen biedt mij een goede kans op een baan.”	☐	☐	☐	☐	☐

Studiekeuze. Hoe belangrijk vind je de volgende aspecten bij het kiezen van een vervolgstudie **voor jezelf**? Kruis aan in hoeverre je het eens bent met de stelling: **“dit vind ik belangrijk in mijn vervolgstudie”**

Stelling: “dit vind ik belangrijk in mijn vervolgstudie”	1 Helemaal mee **on**eens	2 Beetje mee **on**eens	3 Neutraal	4 Beetje mee eens	5 Helemaal mee eens
63) Interessante inhoud	☐	☐	☐	☐	☐
64) Past bij wat ik kan	☐	☐	☐	☐	☐
65) Toegang tot aantrekkelijke beroepen	☐	☐	☐	☐	☐
66) Goede kans op een baan	☐	☐	☐	☐	☐
67) Brede beroeps keuzemogelijkheden	☐	☐	☐	☐	☐
68) Maatschappelijk gericht	☐	☐	☐	☐	☐
69) Uitdagend, veel inzet vereist	☐	☐	☐	☐	☐
70) Veelzijdig	☐	☐	☐	☐	☐
71) Theoretisch	☐	☐	☐	☐	☐
72) Praktisch	☐	☐	☐	☐	☐
73) Anders, n.l.; ………………………………………………..	☐	☐	☐	☐	☐

Talent. Kruis aan in hoeverre je het eens bent met de stelling: **“ik kan dit goed”**.					
Stelling: “ik kan dit goed”	1 Helemaal mee **on**eens	2 Een beetje mee **on**eens	3 Neutraal	4 Een beetje mee eens	5 Helemaal mee eens
74) Natuurkunde	☐	☐	☐	☐	☐
75) Biologie	☐	☐	☐	☐	☐
76) Wiskunde B	☐	☐	☐	☐	☐
77) Natuurkunde, wiskunde, techniek en biologie combineren	☐	☐	☐	☐	☐
78Goed wetenschappelijk onderzoek leren doen	☐	☐	☐	☐	☐
79) Laboratoriumwerk	☐	☐	☐	☐	☐
80) Programmeren: een wiskundig model bouwen met de computer	☐	☐	☐	☐	☐
81) Techniek: werken met en begrijpen van apparaten	☐	☐	☐	☐	☐

Achtergrond vragen				
Wat waren je cijfers op je laatste rapport voor de volgende vakken? Vul in als je het vak in je pakket hebt.	**82) Natuurkunde** ………………	**83)Wiskunde B** ………………	**84) Biologie** ………………...	**85) Scheikunde** ………………...
86) Ben je meisje of jongen?	☐ **Meisje**	☐ **Jongen**		
87) Welk profiel doe je?	☐ **NT**	☐ **NG**	☐ **Anders n.l.;** ……………………………………	
88)Welke van de volgende vakken doe je? (Meer dan één antwoord mogelijk)	☐ **Biologie**	☐ **Wiskunde B**	☐ **Natuurkunde**	
89) Welke (verplichte en vrije) keuzevakken doe je?	……………………………….……………………………………...			
90) Heb je al besloten welke (soort) vervolgopleiding je wilt gaan doen? ☐ **Ja** ☐ **Een beetje** ☐ **Nee**	91) Zo **Ja** /**Een beetje**, welke (soort) opleiding? …..……………………………… …………………………………..	92) Zo **Nee** /**Een beetje**, hoe schat je de kans dat je een technische vervolg-opleiding kiest?	☐ **Heel hoog** ☐ **Hoog** ☐ **Laag** ☐ **Heel laag** ☐ **…………**	
93) In welk van deze categorieën herken jij jezelf het meest? Kruis slechts één antwoord aan.	☐ **Ik ben een doe-het-zelver en wil graag weten hoe iets werkt. Ik kijk graag tv-programma’s als ‘Myth Busters’ en ‘How it is made’.** ☐ **Ik heb vooral interesse voor de theoretische kant van de exacte wereld. Ik vind het belangrijk om met mijn toekomstige opleiding een goede baan te kunnen vinden.** ☐ **Ik wil graag iets nuttigs doen voor de samenleving.** ☐ **Ik wil graag een baan die ik echt leuk vind, iets met mensen, iets met de maatschappij en/of iets internationaals.**			

Heel erg bedankt voor het invullen van deze enquête en succes met je eindejaarstoetsen!
Ammeret Rossouw *(master student “Science Education and Communication” TU Delft, in opdracht van TNW Voorlichting)*