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THE IMPACT OF THE CLASSROOM ENVIRONMENT

Exploring how the classroom environment in secondary schools can enhance the student's learning experience.

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Colophon

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Preface

This master's thesis marks the completion of my MSc in Management in the Built Environment at Delft University of Technology. My fascination with the built environment has always been rooted in its quiet, yet profound, influence on how we live, feel, and learn. During this research, that curiosity narrowed to one particular question: *How do the spaces where we learn shape who we become?*

Along the way, I came to realise how often classrooms — the very spaces where young minds spend most of their days — are designed without truly listening to the students who inhabit them. Their voices, though central, are rarely part of the conversation. This realisation became the heart of my research: to explore how design decisions can genuinely support the learning process of those students.

I would like to express my sincere gratitude to my mentors, Dr. Ir. Monique Arkesteijn, Dr. Ir. Sake Zijlstra and Dr. Ing. G. van Bortel, as well as to the delegate, Dr. Ir. M.C. Lugten, for their valuable guidance, constructive feedback, and continuous support. I am also deeply thankful to the participating schools and students for their openness and involvement — without their collaboration, this research would not have been possible. They are living proof that learning environments are not merely designed — they are *lived*.

I hope this study offers not only theoretical insights but also practical value for designing learning environments in which every student feels heard, seen, and supported.

Delft, October 2025
Beyza Tokyay

Abstract

This study explores how the design and use of classroom environments influence the learning experience of secondary school students. Building on existing literature, the research established a framework of four design categories—Essential, Supportive, Aesthetic, and Functional—comprising sixteen design and use elements. Satisfaction, motivation, and productivity were identified as the most suitable indicators, and the empirical analysis showed these dimensions to be strongly interrelated, forming one integrated construct of the student learning experience. The central research question is: *How does the design and use of classroom environments influence the learning experience of secondary school students?*

Using a mixed-methods approach, two contrasting case studies were analysed through five classroom observations, student surveys (n = 173) and reflective teacher interviews. Results revealed significant correlations between design elements and student experience, with spatial clarity, visual appearance, and emotional support emerging as particularly influential. Conversely, poor environmental quality and limited flexibility and comfort consistently undermined outcomes.

The findings highlight a clear hierarchy: securing baseline essentials of comfort and flexibility is indispensable, while aesthetic and supportive features enrich learning only when these foundations are in place. Classrooms thus act as active determinants—functioning as a "third teacher" that shapes student performance and wellbeing.

Key words:

Student learning experience, Classroom environment, Satisfaction, Motivation, Productivity, Learning Environment, Secondary Schools, and *Design Elements*.

Executive Summary

Introduction

Classroom environments are a critical but often underexplored factor in secondary education. While much attention is given to curriculum and pedagogy, the physical and functional qualities of the learning environment also play a decisive role in how students experience and perform at school. This thesis addresses the central question:

How does the design and use of classroom environments influence the learning experience of secondary school students?

The study builds on the understanding that classrooms are not passive backdrops, but active environments that shape how students feel, engage, and perform in their daily school life. Within this research, satisfaction, motivation, and productivity are identified as the key indicators of student learning experience. The empirical analysis further demonstrates that these dimensions are strongly interrelated and can be regarded as complementary aspects of a single construct: *the student learning experience*. By integrating theoretical perspectives with empirical investigation, this study examines which design and use factors most strongly determine this experience, and how these insights can inform the future management of classroom environments.

Methodology

This research adopts a mixed-methods case study approach to examine how classroom design and use impacts student learning experience in Dutch secondary education. While quantitative and qualitative data are both collected, the study remains descriptive-exploratory in nature.

The research design followed three main phases:

1- Literature review & classroom observations: the review established the theoretical foundation, identifying three core perspectives (educational, pedagogical, spatial) and refining Dahlan's model into a framework of four categories and sixteen design elements (see figure 0.2). This framework served as an analytical lens to systematically observe and assess the current classrooms. In this way, theoretical insights were directly connected to the empirical setting.

2- Student surveys: A total of 173 students, distributed across two case study locations and five classrooms, completed surveys assessing how their classrooms scored on the design and use elements and determining which specific spatial characteristics influenced their satisfaction, motivation, and productivity. These indicators were chosen as primary measures of the *student learning experience*, and statistical analysis later confirmed their strong intercorrelations, indicating they represent complementary aspects of one overarching construct.

3- Teacher interviews: Reflective interviews with teachers from the observed classrooms provided contextual depth, offering pedagogical perspectives and confirming or nuancing student-reported patterns.

A methodological triangulation between literature, student data, teacher insights, and classroom observations enabled a multi-dimensional understanding of classroom environments. Figure 0.1 summarises the research design, while the conceptual model (Figure 0.2) illustrates which design elements and personal characteristics interact to influence the student learning experience.

The research was structured around four sub-questions, each corresponding to a specific phase of the study. The literature review addressed which design and use aspects contribute to supportive learning environments (SQ1) and identified suitable indicators for measuring the student learning experience (SQ2). The student surveys then examined how secondary school students experience their current classrooms and how this affects satisfaction, motivation, and productivity (SQ3). Finally, teacher interviews and the synthesis of all findings provided the basis for translating insights into recommendations for future classroom management (SQ4), see figure 0.1.

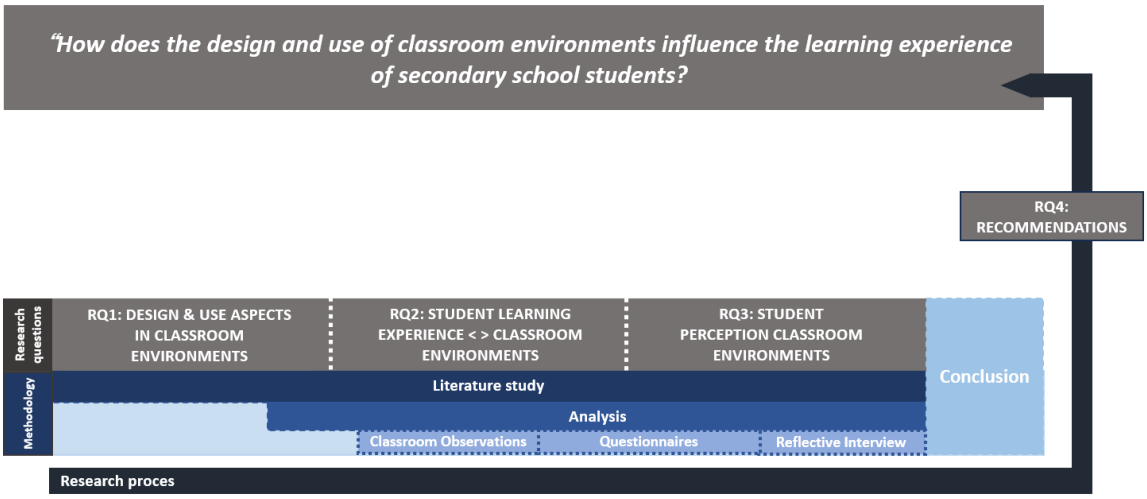

Figure 0.1 – Research Design and Methodology (Source: Own Figure).

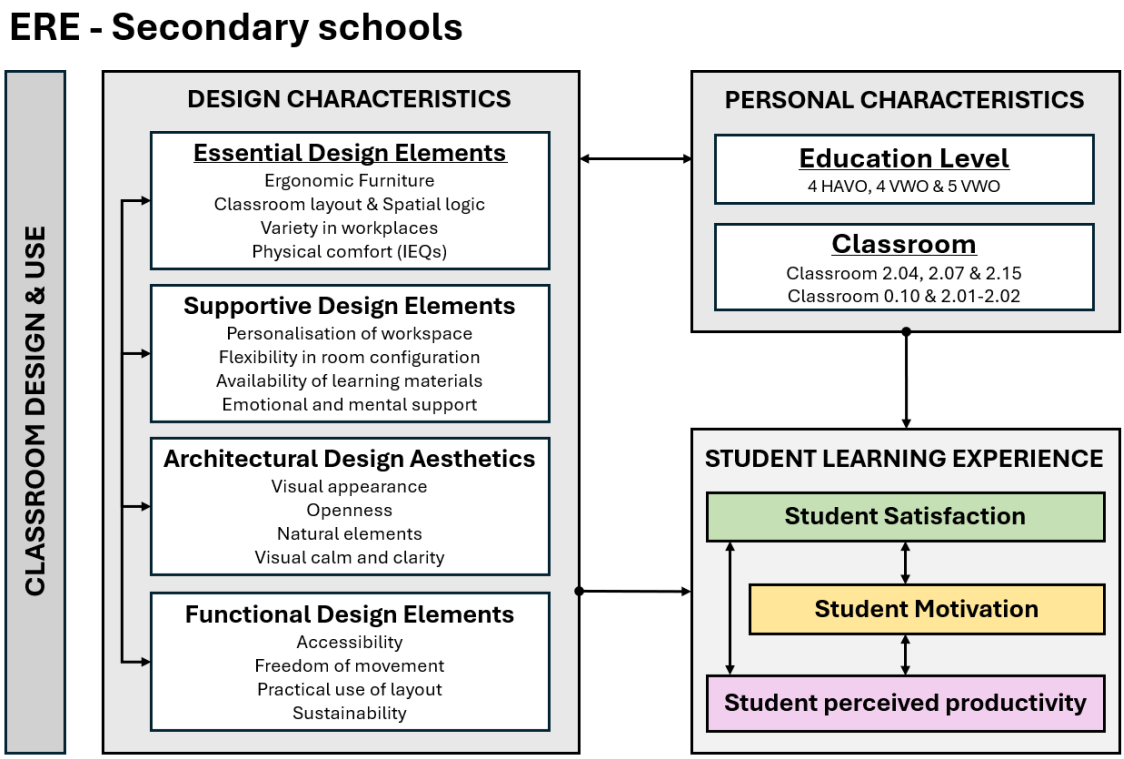

Figure 0.2 - Conceptual model: Research focus [Source: Own Figure].

Research findings

The empirical analysis revealed that the design and use of classrooms have a direct and measurable influence on how students experience their daily school life. Across the surveys, several design elements showed highly significant positive correlations with the student learning experience, most notably ergonomic furniture (C101), variety of workspaces (C102), spatial logic and layout (C103), visual appearance (C301), and emotional/mental support (C204). The results show that physical comfort, together with flexible and varied classroom layouts, consistently emerge as decisive conditions shaping student satisfaction, motivation, and perceived productivity.

An important outcome of the study is that satisfaction, motivation, and productivity—traditionally treated as separate dimensions—are strongly interrelated and can be understood as complementary aspects of a single construct: the student learning experience. When baseline essentials such as ergonomic seating, clear layout, and adequate indoor environmental quality were present, students perceived their classrooms as supportive, engaging, and enabling. When one of these essentials were lacking, as in the case of poor indoor environmental qualities in classroom 2.04, overall learning experiences scored lower sharply—even when other qualities such as aesthetics or clarity were present.

This establishes a hierarchy of impact: securing baseline essentials of comfort and flexibility is non-negotiable, while aesthetic qualities and supportive design features provide added value only when these foundations are in place. Teacher reflections confirmed this pattern, emphasising that inflexible or poorly designed classrooms not only reduce student engagement but also constrain pedagogical possibilities. As one teacher emphasised in the interviews, effective classrooms are those that adapt to the needs of the lesson rather than forcing teachers to adapt their pedagogy to spatial limitations.

Conclusion

To give an answer to the main research question, this study demonstrates that classroom environments shape the student learning experience in direct and measurable ways. The analysis shows that satisfaction, motivation, and productivity function as one integrated construct, significantly conditioned by the quality of classroom design and the way spaces are used.

From this perspective, the influence of design and use is twofold. First, classrooms provide the baseline conditions that allow students to feel comfortable, engaged, and capable of sustaining effort. Second, when these conditions are secured, the classroom can enrich learning further by supporting flexibility and variety, offering autonomy, and enhancing wellbeing. The study also shows that design and use are inseparable: even strong design loses its impact if not aligned with pedagogy, while teaching quality cannot compensate for poor environmental conditions.

The overall conclusion is therefore that classroom environments act as active determinants rather than backdrops of the learning experience. As already argued by the Italian pedagogue Loris Malaguzzi in the 1940s, the classroom should be recognised not as a passive backdrop but as the “third teacher”: a central actor in the educational process. For schools, this means that managing classroom environments is not simply about maintenance or aesthetics, but about creating the conditions in which students can not only perform but truly thrive.

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Motivation

An inspiring and well-thought-out learning environment is never a coincidence. *You immediately feel the difference when a school building is designed with care – not only functional and aesthetically pleasing but also a space where students feel comfortable, focused, and motivated to learn. The physical learning environment plays a crucial role in shaping students' educational experiences, influencing their well-being, interactions, and even their academic performance. Many educational buildings prioritize efficiency and functionality, neglecting the deeper question: What kind of environment truly enables students to thrive?*

Schools shape more than just academic success; they influence how students interact, how they feel, and how they engage with learning. Yet, conversations about education tend to focus on curricula, teaching methods, and policies, while the physical spaces in which learning takes place receiver far less attention. The classroom, the corridors, the communal areas – these are not neutral backdrops but active participants in the learning experience.

Despite growing awareness of this connection, school environments are still rarely designed with students' perspectives at the forefront. Many existing buildings fail to adapt to modern educational needs, overlooking factors like flexibility, comfort, and sensory well-being. Spaces that should stimulate concentration and collaboration often do the opposite, creating barriers to engagement rather than supporting it.

This research seeks to bridge the gap by exploring how the design and use of educational real estate can actively contribute to the students learning experience. By understanding what works – and what doesn't - there is an opportunity to move beyond the traditional idea of school buildings as static structures and instead see them as dynamic, evolving spaces that respond to the needs of those who use them every day. Schools should not just house education; they should enhance it.

The insights from this research provide practical recommendations for architects, school administrators, and policymakers, aiming to create learning spaces that are both functional and inspiring. The space in which learning occurs makes all the difference.

- Beyza Tokyay

List of Acronyms

ERE	Educational Real Estate
RE	Real Estate
REM	Real Estate Management
CREM	Corporate Real Estate Management
IEQ	Indoor Environmental Quality
PoR	Program of Requirements
WBS	Global citizenship (Wereldburgerschap)

PART I -

Introduction & (pre)research

Chapter 01. Introduction

"The school building is not just a structure of bricks and steel; it is the foundation upon which futures are built, dreams are nurtured, and minds are transformed."

This belief marked the starting point of this research: a conviction that the spaces in which we learn are not merely passive backgrounds to the learning process, but active agents that shape it. The layout of a room, the way light enters, the comfort of a chair, or the atmosphere a space creates can influence how students feel, how they focus, and how they learn. This way of thinking led to one central question: ***How does the design and use of classroom environments influence the learning experience of secondary school students?***

1.1. Introduction

In recent years, we acknowledged that within the evolving landscape of education, the physical learning environment serves as far more than just a functional space. They are dynamic environments that continuously evolve to meet the changing demands of education, organisation, and the students. While traditional educational research has focused predominantly on teaching quality and curriculum design (British Council for School Environments, 2010), increasing attention has been given to the role of the physical learning environment in shaping educational outcomes. This shift acknowledges that well-designed educational real estate (ERE), referring to the physical and spatial environment in which education takes place, is an important component of effective learning, capable of significantly influencing student behaviour, engagement and performance (Hanaysha, Shriedeh, & In'airat, 2023; Barrett et al., 2013; Bluyssen et al., 2020). These findings emphasise that RE decisions should extend beyond financial and operational concerns, and integrate pedagogical and educational considerations to maximise their effectiveness in the learning environments (Yeoman & Wilson, 2021).

Yet, despite this growing recognition, we notice that the classroom environments, the place in which students spend most of their school day, receive less structured attention and a more systematic look than it deserves (Appel-Meulenbroek et al., 2019). The classroom is the space where teaching strategies are implemented, where cognitive and emotional states are shaped, and where the learning experiences becomes tangible. Despite its centrality and importance, classroom design is often overlooked in ERE strategies, which tend to prioritise organisational efficiency or overall building concepts, rather than the daily lived experience of students. Traditionally, ERE has been viewed as a logistical necessity, with a strong focus on cost-efficiency, space efficiency, and regulatory compliance (Appel-Meulenbroek et al., 2019; de Vries, 2007). This perspective aligns with broader REM principles, where properties are seen as (fixed) assets that must be managed, rather than as dynamic elements influencing education (Kariippanon et al., 2017).

Despite that the classrooms nowadays are designed similar to our well-known classrooms; we notice a deeper understanding of how ERE can influence and even benefit learning according to literature. Kariippanon et al. (2017) highlighted the importance of spatial flexibility in classrooms, such as multifunctional and adaptive learning environments, to support educational demands. Bluyssen et al. (2020) demonstrates how technical aspects of the indoor environment, such as lighting, air quality, and acoustics (IEQ), affect concentration and cognitive performance. However, these studies tend to analyse the learning environment in technical terms, often omitting the user perspective. Zain & Ramli (2019) and Kuok Ho (2023) show that aesthetically pleasing and well-maintained spaces can enhance student's intrinsic motivation and sense of ownership, yet their findings are frequently framed from a design or behavioural science angle rather than through direct student input.

What is notably missing in these studies is a consistent and in-depth engagement with the student voice. This study addresses the gap by empirically testing these often-assumed relationships using student-reported data, rather than relying on theoretical or observational claims alone. Only a few researchers have directly asked students how they experience their learning environments or included them in the design

and evaluation process (Bluyssen et al., 2020; Thomas, 2012). This is a critical oversight, as students - being the primary users of classrooms – can offer valuable insights into how spatial qualities translate into emotional and cognitive responses (Azam, 2018; Osman & Saputra, 2019). When students are involved, a deeper and more nuanced understanding of the relationship between learning spaces and educational outcomes can be achieved.

Building on the philosophy of Loris Malaguzzi and the Reggio Emilia approach, which describes the environment as the "Third Teacher" (Thomas, 2012), this research positions the classroom not as a passive background, but as an integral part of the learning process. What happens in the classroom is shaped not only by what is taught, but also by how space enables or hinders learning. Still, in many design processes in practice, students remain unheard.

This study aims to bridge the gap. It focuses on how classroom design and use impact student´s learning experiences. Rather than analysing entire school buildings, the study narrows its scope to the classroom: a clearly defined, high-impact environment that is both comparable across settings and deeply connected to student's day-to-day educational experiences.

By isolating the classroom as a unit of analysis, this research enables a more targeted exploration of design factors. It focuses on four dimensions: *essential elements, supportive elements, architectural aesthetics, and functional elements*, and investigates how these influence the student's learning experience. This structure makes the findings not only academically relevant, but also practically applicable for architects, school leaders, and policy makers.

1.2. Problem Statement

In the context of secondary education, the alignment between educational ambitions and the physical learning environment remains a persistent challenge. Despite rising awareness of the importance of ERE, studies continue to show that existing school buildings often fail to respond to the evolving needs of modern education (Sasson, Yehuda, Miedijensky, & Malkinson, 2021). As Annet Dries, vice-chair of the PO-Raad (the sector organization for primary education), stated (2025), we expect education to provide tailored approaches, personal guidance, innovation, and inclusion. However, the buildings in which all of this is supposed to take place are not designed to support these aims. The ambitions of education nowadays do not fit within the school built earlier (Dries, 2025)

This issue was already signalled in earlier research. De Vries (2007), for instance, revealed that both the current building stock and future construction plans rarely align with institutional identity, pedagogical visions, or organisational objectives. Similarly, the Dutch Service centrum Scholenbouw (2006) warned that existing school buildings, especially in primary and secondary education, often could not support the growing need for flexible and multifunctional spaces. Also, researchers from the TU Delft (Arkesteijn et al., 2007) confirmed this, concluding that traditional school infrastructure lacked the spatial adaptability needed to support evolving educational concepts. These early signals pointed to a structural mismatch between educational supply and spatial demand.

More recent studies confirm that this misalignment remains relevant today. For example, research by Kariippanon et al., (2017) indicates that many schools still operate in buildings that hinder collaboration, innovation, and student-centred learning due to inflexible layouts and outdated design principles. Despite developments in educational thinking, physical spaces often continue to lag behind (Sasson et al., 2021), failing to evolve with the pedagogical strategies they are intended to support.

Frameworks such as DAS (Designing an Accommodation Strategy) (De Jonge et al., 2009) offers a structured approach to aligning spatial supply and educational demand, see figure 1.1. They distinguish between quantitative aspects (e.g. surface area) and qualitative attributes (e.g. spatial comfort, flexibility, identity). However, in practice, school buildings are still often planned and evaluated on measurable input variables, rather than user-centred educational outcomes (Thomas, 2012).

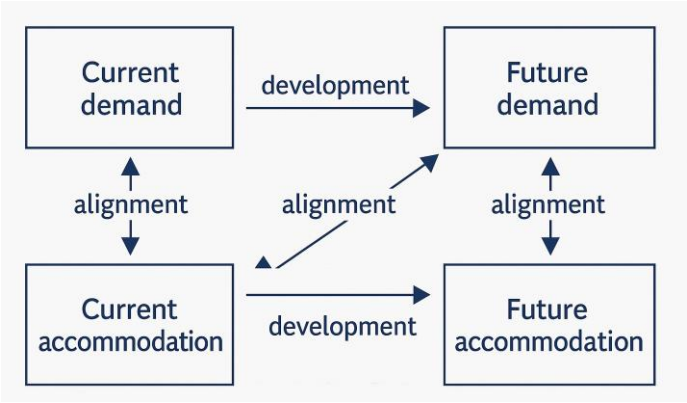


Figure 1.1 - DAS Framework [De Jonge et al., 2009].

This problem becomes especially urgent when we zoom in on the classroom. Despite being the central setting for daily learning, classrooms are frequently standardised and rarely designed with the learner's perspective in mind (Dahlan, 2013). If we truly wish to improve educational performance through better spatial environments, we must understand how students experience these classrooms, and how those experiences influence their learning experience (Appel – Meulenbroek et al., 2023; Kuok Ho, 2023). This study contributes to the field by going beyond the assumptions and providing empirical evidence from student-reported data to substantiate how classroom environments impact the student learning experience.

1.3. *Research focus*

The aim of this research is to explore how classroom environments influence learning not only from a physical or technical perspective but through the lens of student learning experiences. The student learning experience is measured by three constructs: *Student Satisfaction, Student Motivation* and *Student Self-Perceived Productivity*, as will be explained further in chapter 3.

The central hypothesis leading this study is that when the design and use of the classroom are optimised to meet student's needs, it will increase their student learning experience. These improvements in the learning experience may, as suggested in existing literature, contribute to better academic performance over time.

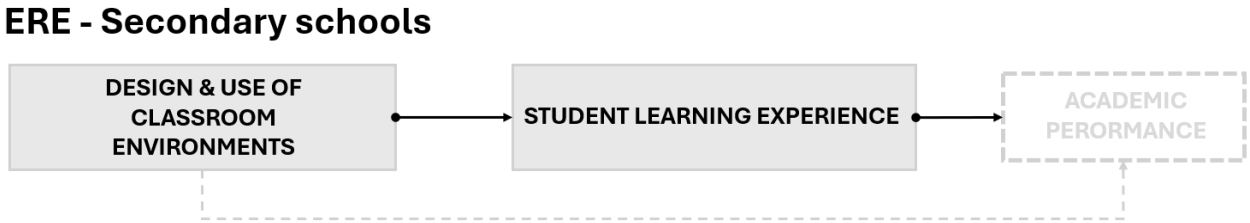


Figure 1.2. – Preliminary conceptual model based on research question [Source: Own Figure].

However, it is important to note that academic performance itself is not directly measured in this study due to ethical considerations and time constraints that limit long-term data collection, despite its theoretically acknowledged impact. Therefore, the design and use elements of classroom environments are measured against the three mediators of the student learning experiences: satisfaction, motivation, and self-perceived productivity, see figure 1.3 for the conceptual model with the variables in the dataset. This study contributes to the field by going beyond the assumptions and providing empirical evidence from student-reported data to substantiate how classroom environments impact the student learning experience.

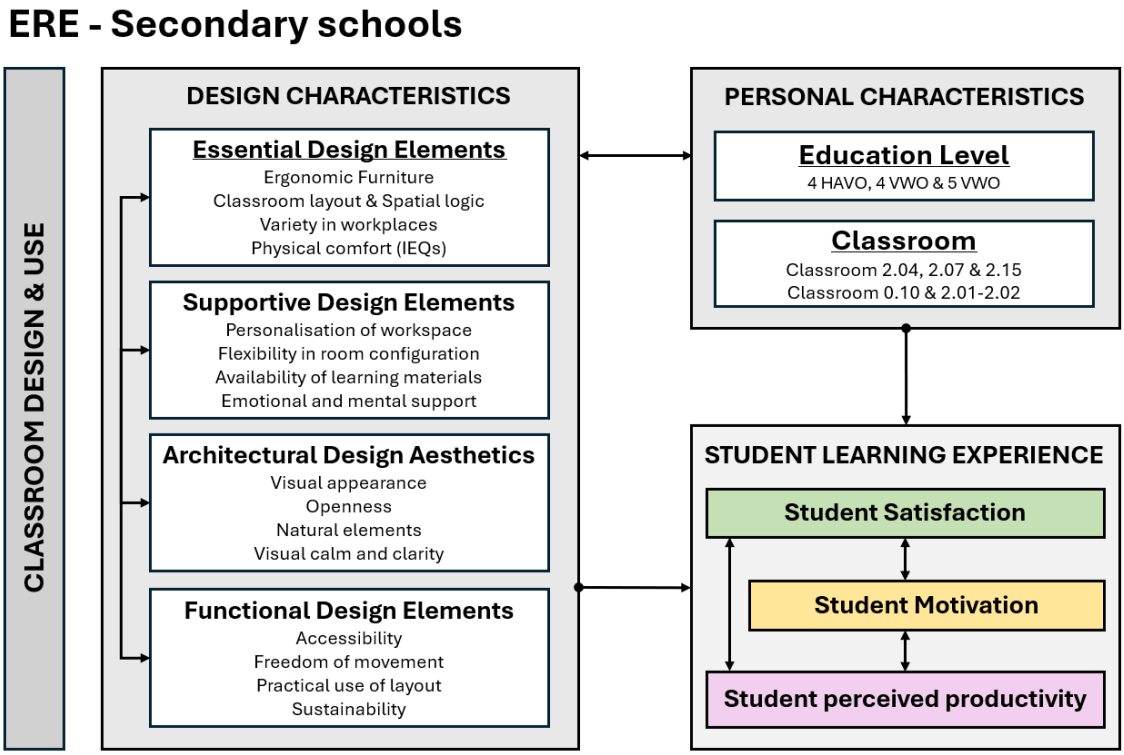


Figure 1.3 - Conceptual model: Research focus [Source: Own Figure].

While some of the design and use elements have already been examined in depth and are supported by empirical evidence, others remain largely assumption based. For instance, research shows that ergonomic furniture can enhance comfort and productivity by around 12% (Barrett et al., 2015), that providing a variety of workplaces can increase motivation and engagement by approximately 31% (Kariippanon et al., 2017), and that poor indoor environmental quality (IEQ) may cause up to 25% loss in cognitive performance (Bluyssen et al., 2020). By contrast, many other spatial characteristics are less well researched, and their influence is often assumed rather than demonstrated. By examining both types of elements, this study not only validates existing findings within the context of Dutch secondary schools but also enables a direct comparison with less-studied design aspects, many of which are still grounded in assumptions. In doing so, the research moves beyond assumptions and empirically tests the full set of classroom design and use characteristics, as further discussed in Chapter 3.

In this context, the term *design* refers to the physical and spatial features of the classroom – its intended appearance and layout – while *use* refers to how these spaces are actually experienced and used by students and teachers (Thomas, 2012).

Without insight into the *design*, usage data remains contextless: we do not know *why* something does or does not work well. As outlined in several studies, the physical characteristics of classrooms - such as colour schemes, spatial perception, temperature (IEQs), and choice of materials - significantly influence how students feel in a space (Barrett et al., 2015). In turn, these perceptions have been shown to affect students learning experience (Kariippanon et al., 2017).

Importantly, use cannot be approached purely as a behavioural phenomenon—it is a response to what the environment enables or restricts. If one only considers usage, it risks overlooking the underlying design factors that either facilitate or hinder that use. For example, in practice, classrooms with limited access to power outlets often see reduced laptop usage by students—not due to a lack of willingness, but because the design does not support it.

Research that focuses solely on *use* tends to lean toward behavioural studies, while leaving the underlying spatial and environmental factors unexplained. Conversely, studies that focus exclusively on *design*,

without accounting for how it functions in practice, often remain too abstract. By integrating both perspectives—design and use—this study acknowledges the complex interplay between space and behaviour.

This research explores the classroom environment by analysing four distinct yet interrelated categories of design characteristics: *Essential Design Elements, Supportive Design Elements, Architectural Design Aesthetics,* and *Functional Design Elements,* see figure 1.3. These categories offer a structured framework for examining how both the physical configuration *(what the space is)* and the practical application *(how the space is used)* contribute to student's learning experiences, as will be explained further in chapter 3.

In line with paragraph 3.3, the student learning experience is operationalised through three mediators — student satisfaction, student motivation, and self-perceived productivity — capturing the affective, behavioural, and functional dimensions of classroom experience, respectively. While these dimensions are conceptually distinguished in paragraph 3.3, the statistical analysis in chapter 4 shows they are strongly interrelated and internally consistent (Cronbach's $\alpha = 0.90$; inter-item correlation = 0.81), indicating that they also form a robust single construct. Accordingly, results are reported both at the level of each mediator and, where appropriate, in aggregate.

By centring the student in the analysis, this study explores how the physical classroom environment supports learning. It examines how spatial elements are designed and used in practice to reveal which qualities matter most, how they are experienced, and how design improvements could enhance daily school life. Unlike many previous studies that base their conclusions on assumptions or observations, this research aims to empirically validate the relationship between classroom design, use, and the student learning experience using direct input from students themselves.

This leads to the following main research question:

How does the design and use of classroom environments influence the learning experience of secondary school students?

This can be answered by the following sub-questions:

1) Which design and use aspects, identified through literature, contribute to a classroom environment that supports student learning experiences?
2) Which indicators are suitable for measuring the student learning experience in relation to classroom design and use?
3) How do secondary school students experience their current classroom environment and how does it influence their learning experience with focus on satisfaction, motivation and productivity?
4) How can the insights into design and use be translated into concrete recommendations for the future management of classroom environments?

Answering all these questions should result in a final product with the following objective:

The objective of this research is to gain insights into the relationship between classroom design and use characteristics and the student learning experience in secondary schools. The findings aim to inform practical recommendations for optimising educational spaces in ways that enhance student learning experience with focus on satisfaction, motivation, and perceived productivity—factors that, according to literature, may contribute to the overall learning experience of students.

1.4. *Structure of the report*

This thesis is structured into three main parts, moving from theory foundations and literature review to empirical analysis and practical outcomes. Each part builds upon the previous one to answer the central research question.

Part I – Introduction and methodology
This section introduces the context, research motivation, and methodological framework. It defines the problem, outlines the main research question and sub-questions, and describes the research design and data collection methods.

Part II – Research foundation
This part presents the theoretical framework and literature review. It explores relevant perspectives on the classroom environment and student learning experiences with focus on *student satisfaction, motivation, and productivity*. It also develops the conceptual model guiding the analysis.

Part III – Research findings, discussion, conclusion and reflection
The final part contains the empirical study, including the case analysis, survey results, and interviews. It concludes with a discussion of the findings, practical recommendations for design, and reflections on the research process.

Chapter 02. Research methodology

2.1. *Study Design*

This research investigates the relationship between the classroom environment and its influence on student learning experiences, with focus lying on *student satisfaction, motivation,* and *self-perceived productivity*, within the context of Dutch secondary schools. The classroom is considered the most frequently used and pedagogically significant space within a school, making it a suitable unit of analysis for understanding how spatial characteristics contribute to the daily learning experience. The research model, as shown in figure 2.1, serves as a visual representation of the design and is further explained below.

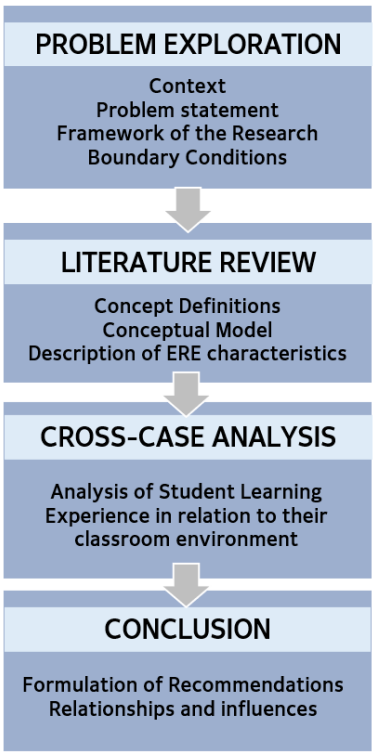


Figure 2.1 - Research Structure [Source: Own Figure].

This research adopts a mixed-methods case study approach, supported by both quantitative (survey data) and qualitative (interview data) methods. The research is situated in the context of Dutch secondary education and aims to explore how the spatial characteristics of classrooms design and use influence student learning experiences. The choice for this design is twofold: first, it allows for both depth and context sensitivity by combining quantitative and qualitative data; second, it aligns with the descriptive-exploratory nature of this study, which aims to understand spatial impact through the lens of the student. Two schools were selected as cases based on their contrasting architectural design and spatial layout of their classrooms.

The study is structured in two sequential phases:

- **Phase 01 – Student survey:** Phase one consists of a structured student survey, deployed across selected classrooms in two different schools with contrasting classroom layouts. The survey captures the student's experiences and their perceptions on satisfaction, motivation and productivity – the three core indicators of student learning experience used in this study. Responses are collected across four key spatial domains: *Essential design elements, Supportive design elements, Architectural Aesthetics, Functional design elements.*

- **Phase 02 – Reflective interviews with schoolteachers:** Phase two involves semi-structured reflective interviews with teachers from both schools who are familiar with the selected classrooms. These interviews are designed to reflect on the survey outcomes and triangulate the findings regarding student experiences within those classrooms.

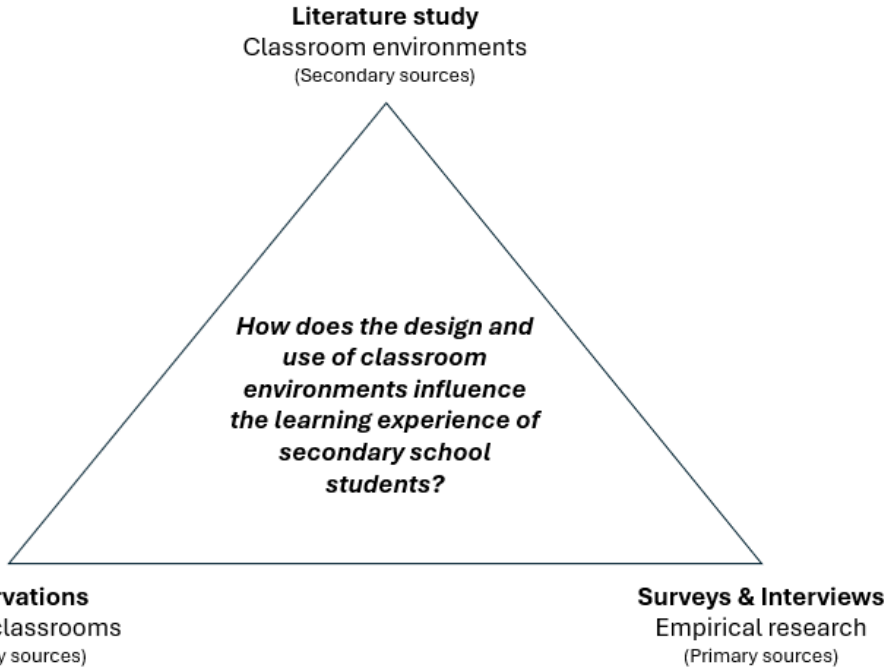


Figure 2.2 – Methodological triangulation research [Source: Own Figure].

Triangulation approach & descriptive-exploratory study

This study applies *methodological triangulation* by combining three different sources and methods of data collection (Blaikie & Priest, 2019): (1) a literature review summarising existing theoretical and empirical insights on classroom environments, (2) classroom observations to capture contextual and physical characteristics, and (3) quantitative and qualitative data from student surveys and teacher interviews. This combination enhances the reliability and validity of the findings by approaching the research question from multiple perspectives, allowing the data to complement or challenge each other (Fetters, Curry, & Creswell, 2013). By integrating both secondary sources (literature) and primary data (observations and surveys/interviews), the research produces a richer and more layered understanding of how classroom design and use influence the student learning experience.

The overall research design can be characterised as a quantitative, descriptive–exploratory study. While the analysis is based on quantitative data derived from student surveys and classroom observations, the research maintains an exploratory aim: to identify and describe emerging relationships between classroom design, classroom use, and students' learning experience. This approach is appropriate because, as Blaikie and Priest (2019) note, exploratory studies are particularly useful when the goal is to uncover new patterns that can guide future explanatory or hypothesis-driven research. In this study, the exploratory character lies in the search for meaningful relationships between spatial, ergonomic, and experiential variables, whereas the descriptive dimension is reflected in the systematic, quantitative assessment of these variables. Consequently, the study does not seek to establish causal relationships but rather to generate structured, data-driven insights that can inform both theory and practice in the design and management of educational environments. Therefore, the following research question guides the study:

> ***How does the design and use of classroom environments influence the learning experience of secondary school students?***

2.2. *Data Methodology*

To answer the main research question, this study adopts mixed-methods approach. While both quantitative and qualitative data are collected, see figure 2.3, the interpretation and purpose of the study remains primarily descriptive-exploratory. This methodology was chosen to obtain both measurable and interpretive insights into how classroom environments influence student´s learning experiences, with a particular focus on student satisfaction, motivation and productivity as key indicators.

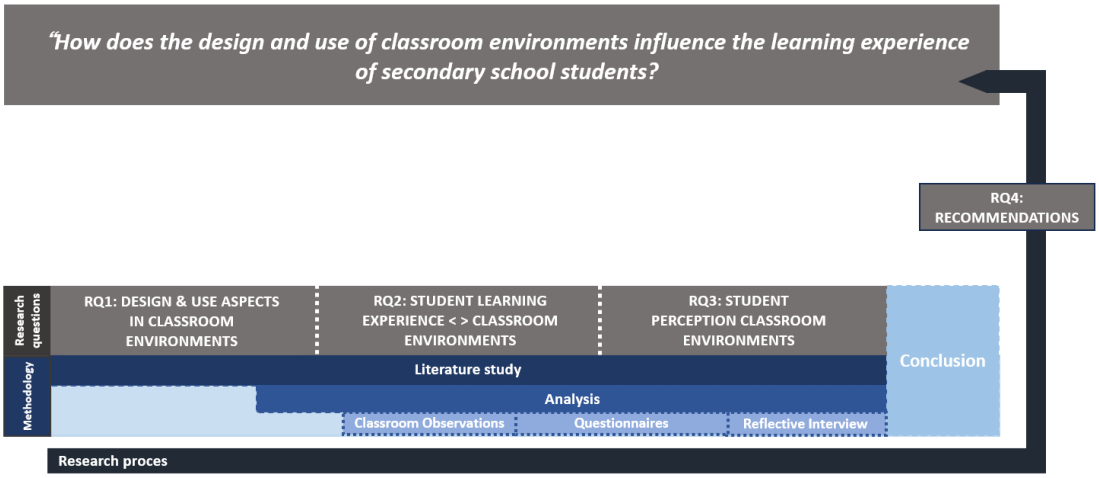


Figure 2.3 – Research Design and Methodology (Source: Own Figure).

Case studies form the foundation of this research. Two secondary schools were selected based on significant differences in RE characteristics, enabling a comparative analysis. The first sub-question focuses on identifying design and use aspects of the classroom environment. Diverse perspectives on education (educational, pedagogical and spatial) are analysed to determine how these are reflected in actual classroom design and usage according to literature. The literature review provides an initial foundation for understanding these insights and will be used to observe the current selected classrooms in each case study.

The second sub-question focuses on how students' learning experiences can be analysed from their own perspective. This is assessed through three key indicators: satisfaction, motivation, and productivity. These indicators were chosen because they each represent a relevant and distinct aspect of how students interact with and are affected by their classroom environment.

These three dimensions were originally distinguished in the theoretical framework (see paragraph 3.3), where they are described as a unique yet complementary contribution to understanding how student experience their learning environment. *Satisfaction* primarily relates to the affective dimensions (how students feel in the classroom), *Motivation* addresses the behavioural dimension (the willingness to participate in learning activities), and *Productivity* represents the functional dimension (the perceived ability to complete and perform academic tasks effectively). However, the statistical analysis presented in chapter 4 demonstrates that these dimensions are strongly interrelated and can reliably be combined into a single construct. This empirical findings supports the use of a combined construct in addition to the individual dimensions, allowing the study to examine both the specific and the overall relationships between spatial design characteristics and how students feel, behave, and perform within the classroom setting.

It is important to note that this study does not directly assess academic performance. Measuring academic achievement lies outside the scope of this research due to ethical considerations and time limitations, which prevent the collection of long-term performance data. Therefore, the selected indicators—student satisfaction, motivation, and self-perceived productivity—serve as proxies for evaluating the impact of the classroom environment on the student learning experience.

This approach is supported by recent literature, which suggests that positive learning experiences are often linked to improved academic outcomes over time (Bluyssen et al., 2020; Hanaysha et al., 2023). However, in this study, such outcomes are not directly measured but considered as a potential implication of enhanced learning experiences, rather than a central research objective.

Based on the insights derived from the first two sub-question a structured survey was developed as an instrument to assess student's perceptions of specific RE characteristics and the selected classrooms were observed. The survey focuses on how the classroom environment influences student's learning experiences and the perceived impact on their satisfaction, motivation, and productivity. The observations focus on what is visible and helps to create a context and meaning for the survey results.

The survey was distributed in the selected case study schools, providing a standardized method for capturing these aspects and experiences. The survey was distributed among upper-grade students, from the same educational level (HAVO-VWO), who have more experience with their classroom environment. The survey will be taken at the end of the lesson in the selected classrooms, allowing students to share their experiences immediately. This approach maintains an ecological validity, as responses are based on direct experience rather than memory or abstraction (Blaikie & Priest, 2019). Additionally, conducting the survey in this setting is expected to increase the response rate, ensuring a sufficiently robust sample.

For this study, only upper-grade HAVO and VWO students were invited to participate, as the ethical guidelines required participants to be at least 16 years old. In the Dutch education system, this corresponds to students in 4 MAVO, 4–5 HAVO, and 4–6 VWO. However, final-year students (4 MAVO, 5 HAVO, and 6 VWO) were excluded from participation due to their limited availability and focus on exam preparations during the data collection period.

To analyse the survey data, descriptive and correlational statistical methods were applied to identify patterns and relationships between classroom design elements and student's learning experiences. The analysis focused on mean scores, standard deviations, and correlation coefficients between the spatial design categories and the three indicators of the student learning experience. This analytical strategy enables the detection of statistically meaningful relationships while maintaining interpretive depth consistent with the exploratory and user-centred nature of the study. A regression analysis was not conducted, as the objective of this research is not to predict or quantify causality but to explore relational tendencies and perceived interdependencies between spatial characteristics and student experiences (Blaikie and Priest, 2019). Regression models require large datasets, strict variable independence, and precise control conditions that do not align with the perception-based data collection context of this study. Instead, bivariate correlations and internal consistency tests (e.g. Cronbach's alpha and inter-item correlations) were used to validate the reliability and coherence of the measurement scales. This approach ensures analytical robustness while respecting the contextual limitations of the classroom data and without overstating casual inference.

Following the survey results, reflective interviews were conducted with teachers from both schools who are familiar with the selected classrooms. These interviews allowed teachers to reflect on the survey outcomes and share their perceptions regarding classroom design, use, and how these elements align with student's responses.

The analysis of the collected data provides the foundation for answering the main research question. These insights contribute to a comprehensive understanding of how the classroom environment affects student satisfaction in secondary schools. Furthermore, the results inform practical recommendations (sub-question 4) for architects, school boards, and other stakeholders. The goal is to support more effective design for future classroom environment, potentially extending towards broader ERE considerations.

Although the survey data is quantitative in nature, the research remains descriptive-exploratory. Student responses serve as a starting point of departure for deeper reflection. By integrating both student and teacher perspectives, this study allows for a more comprehensive user-centred understanding of the learning environment, encompassing both experiential and design-oriented dimensions.

2.3. *Data collection techniques & sampling*

As outlined in paragraph 2.2, this research employs an exploratory mixed-method approach to gain insight into the relationship between the classroom environment and the student learning experience consisting of mediators such as student satisfaction, motivation and self-perceived productivity. Data was collected through a combination of secondary data sources and empirical instruments, as described below:

Secondary Data sources

1- **Literature review:** the literature review serves as the foundation for the conceptual model, providing an overview of relevant RE characteristics and their potential relationship with the student learning experience. This theoretical framework identifies key aspects of the classroom environment that contribute to student learning experience by delving into satisfaction, motivation and productivity.

These findings offered important input for framing the empirical data collection and helped ensure relevance and alignment across research phases.

Primary Data sources:

1- **Classroom observations:** Prior to survey distribution, each selected classroom was visited and documented to provide spatial context and help verify the presence (or absence) of key physical features. Observations focused on classroom features, such as:
   - Space usage and square meters.
   - Presence and visibility of the design elements divided into the four categories (chapter 3).

2- **Student survey:**
A structured digital survey was conducted among upper-year HAVO/VWO students (≥16 years) in two different schools. The survey measured student satisfaction, motivation and self-perceived productivity and their experience with design elements using closed-ended Likert-scale questions and a small number of open-ended questions. The questions were grouped around 4 categories as will be explained in chapter 4. The responses are analysed to identify trends and patterns in perceived classroom quality.

3- **Semi-structured interviews with teachers:**
In the second phase, interviews were conducted with teacher from both schools who are familiar with the selected classrooms. These interviews are aimed to reflect on the survey outcomes and triangulate the findings by discussing how classroom design, student responses, and their performances are perceived by the teachers. These conversations were guided by themes emerging from the student data and are focused on the four designs categories. Sample questions included, (see appendix 4 for full interview questions):
   - *Which physical classroom characteristics do you believe have the most impact on their learning experience?*
   - *How do you personally perceive the influence of the classroom on your student's motivation, productivity, and performance?"*

Data & Participants	Type, Form, Source & Format	Selection	Sample size & Response rate
Questionnaire with secondary school students (≥16 years) in selected HAVO/VWO schools.	**Type:** Primary data **Form:** Quantitative **Source:** Semi-natural **Format:** MS Forms (taken during regular class hours)	**Population:** Secondary school students (≥16 years) **Sampling method:** Probability sample	**Initial sample size:** 50 Response rate: 50% = 100 **Actual response:** 110
Interviews with schoolteachers of the selected case units (the classroom).	**Type:** Primary data **Form:** Qualitative **Source:** Semi-natural **Format:** One-on-one, semi-structured interview	**Population:** School teachers from the selected classrooms **Sampling method:** Nonprobability sample	**Initial sample size:** 2 **Response rate:** 25% = 8 **Actual response:** 2

Table 2.1 – Empirical research instruments (Source: Own Figure).

By combining both datasets, the study benefits from methodological triangulation: student perspectives provide insight into direct classroom experience, while schoolteachers perspectives triangulate the findings by discussing how classroom design, student responses, and their performances are perceived by the teachers. This layered approach increases the reliability and contextual richness of the findings.

Although the two methods differ in nature, they are complementary: the survey captures the student experience, while the interviews triangulate the findings. Together, they enable a more complete understanding of how the design and use of classroom environments can support students learning experience by in increasing their satisfaction, motivation, and perceived productivity.

2.4. *Data search*

The data collection process for the literature review in this research was primarily driven by the snowball methodology, a recognized approach in systematic reviews that emphasizes to use references within sources to undercover additional relevant studies (Blaikie & Priest, 2019; Goodman, 1961). This can lead to discovering broader networks of knowledge (Jalali & Wohlin, 2012). The snowball methodology is particularly advantageous in fields with interdisciplinary overlaps, such as ERE and Classroom environment, student perspective and their learning experience, where comprehensive exploration requires navigating literature across architecture, pedagogy, and education (see figure 2.4).

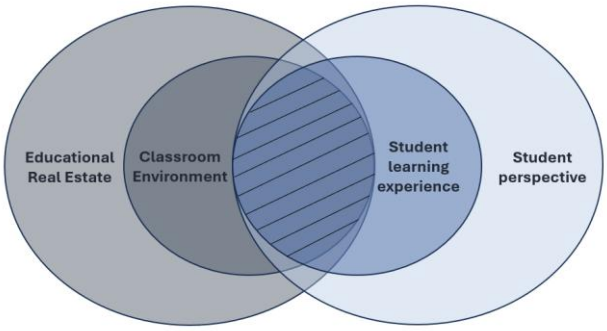


Figure 2.4 - Core elements study [Source: Own]

Initially, a few search terms were formulated and used based on the research questions and the conceptual framework (see figure 2.6 and 2.5). Databases like Google Scholar, Scopus, and Web of Science were employed for the literature study.

("Educational Real Estate" OR "Classroom Environment") AND ("Student perspective" OR "Student learning experience") AND ("User-centered Design" OR "Design Elements") AND ("Secondary schools" OR "Learning space design")

Figure 2.5 – Example of Boolean Search Query in Google scholar, Scopus, and Web of Science [Source: Own]

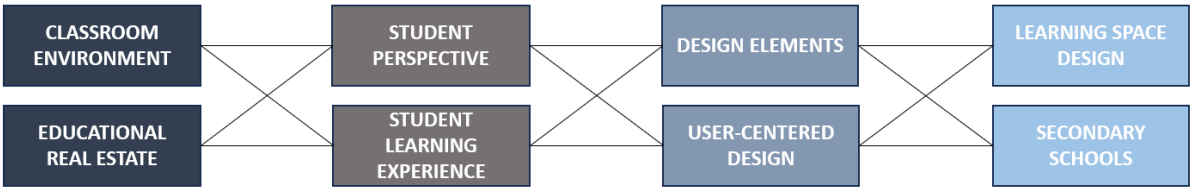


Figure 2.6 - Keywords Research Study [Source: Own]

After identifying foundational articles, the snowball method was initiated. These articles were screened for relevance and quality by first reviewing their titles and abstracts in relation to classroom environments or secondary schools. A subsequent full-text assessment was then conducted to ensure methodological rigor and alignment with the study's objectives. This method helped to include key studies, building a comprehensive literature base. A notable characteristic of the snowball method is its ability to reveal thematic saturation – an essential stopping criterion in qualitative research (Bowen, 2008; Blaikie & Priest, 2019). Saturation was observed when subsequent sources began reiterating previously identified themes, such as the impact of natural lighting on student concentration (Barrett et al., 2013; Bluyssen, 2020) or the mediating role of satisfaction and motivation in educational outcomes (Dahlan, 2013), see figure 2.7. By

combining strategic keyword searches with the snowball method, this study leverages an evidence-based approach to establish a robust theoretical foundation, ensuring academic relevance to the research objectives.

Author	Aspect(s) Impacting Student Learning Experience in Classroom Environments										
Yang et al. (2013)	Visibility	Ergonomics (furniture)	Layout	Accessibility	Technology	Temperature	Air quality	Lighting	Acoustics		
Dahlan (2013)	Way finding	Lighting	Acoustics	Ventilation	Noise	Layout	Interior	Technology	Collaborative spaces	Sustainability	Paint Colour
Leaman (2002)	Natural Light	User control	Breakrooms	Social Interaction	Sense of belonging	Accessibility	Functionality				
Levin (2003)	User control	Lighting	Acoustics	Air Quality	Temperature	Daylight Access					
Barrett et al. (2013)	User control	Flexibility	Way finding	Spatial stimulation	Air Quality	Temperature	Light	Sound	Usability furniture	Daylight access	Social interaction
Van Vliet (2007)	Layout flexibility	Way finding	Transparency	Small (work) spaces	Functional spaces	ICT facilities	Installations	Clustering spaces	Aesthetic appeal		
Elliott (2002)	Sense of belonging	Way finding	Aesthetic appeal	Social Interaction	Collaborative spaces						
Vinci et al. (2024)	Technology	Aesthetic appeal	Sustainability	Flexibility	Ergonomics (furniture)						
4 Categories:	Essential Design Elements			Supportive Design Elements		Architectural Design Aesthetics		Functional Design Elements			

Figure 2.7 - Iteration of key aspects impacting student learning experiences in their classroom environment [Source: Own Figure].

The aspects identified across the literature were clustered into four overarching categories, inspired by Dahlan's (2008; 2013) framework and the aspects identified across the reviewed literature, but refined through my own synthesis and thematic grouping. It was important to first define clearly what each category represents (see chapter 3) after which the aspects could be conceptually assigned to the category that best reflected their primary influence on the student learning experience. From there, I deliberately selected four elements per category that I considered most representative of the category's core qualities based on literature and what directly observable was in the classroom context, for example, ergonomics and indoor environmental qualities under *Essential*, or social interaction and flexibility in room configuration under *Supportive*. This approach ensured a balanced and workable framework for further analysis. In this way, the categorisation, informed by Dahlan's framework and refined through researcher judgement, resulted in sixteen elements that form the analytical basis elaborated in Chapter 3.

2.5. *Case selection criteria*

To investigate how classroom design and use are perceived and experienced by students, this study employs a multiple-case approach. Two case studies were conducted at Dutch secondary schools, complemented by interviews with teachers from both schools. The physical and organisational characteristics of school facilities—such as size, structure, educational vision, location, and ownership—are known to influence student outcomes and experiences (Zain & Ramli, 2019). Therefore, a careful and theoretically grounded case selection process was critical.

To ensure the relevance, comparability, and diversity of the selected cases, a set of case selection criteria were defined prior to data collection. These criteria were formulated based on theoretical considerations (see Chapter 03) and combined with practical considerations related to fieldwork feasibility. The criteria were clearly communicated to (participating) schools via a research one-pager that served as an official invitation and briefing document (see appendix 5).

The selection of cases was guided by a purposeful sampling strategy based on the following selection criteria:

1- **Relevance to target group:** Both schools need to be Dutch secondary education institutions (HAVO/VWO), with students aged 16 years and older (due to the ethical consideration of the TU Delft), ensuring that participants were experienced enough to reflect critically on their learning environments. MAVO schools are not included because only the 4th-year MAVO students would meet the age criterion, but they were unavailable during the data collection period due to their final

exam schedules. Also 5 HAVO and 6 VWO classes were excluded for the same reason, which was partly related to the overall timeline of the study.

2- **Practical accessibility:** The schools had to be willing to participate and allow the surveys to be conducted at the end of the regular lesson hours in specific classrooms, guaranteeing sufficient participation rates, authentic students responses, and clear expressions of their experience within the chosen classrooms.
3- **Classroom condition:** Selected classrooms must either belong to a newly built facilities (≤ 15 years) or have been substantially renovated within the past 5-10 years to ensure a comparable standard of quality.
4- **Architectural design differences:** Both attending schools in the case studies must differ from each other in spatial layout and characteristics in the classroom.
5- **Operational period:** The school must have been operational for at least one year, allowing users to adapt to the environment and provide meaningful feedback.
6- **SES-indicators & Location:** Schools must be located in urban or suburban neighbourhoods with similar SES indicators, ensuring that external environmental factors remain comparable.

The selected cases provided contrasting yet comparable classroom environments. These served as empirical settings to explore how students experience their learning spaces, using the framework and measurement indicators described in Chapter 3. Student survey responses were systematically collected and analysed across the four design categories, offering both depth and breadth in the assessment of learning environments, see figure 2.8.

The empirical case study was conduced at two Dutch secondary schools, selected according to predefined case selection criteria. Two schools with diverse spatial conditions were selected, allowing for comparative analysis of student perceptions across different classroom settings:

- Case A: School A – a newly constructed, featuring traditional classroom layouts and design elements. Three classrooms were selected for in-depth analysis based on their use and design.
- Case B: School B – recently renovated classrooms designed for flexibility and collaboration. Two classrooms were selected based on their adaptive layouts and varied functional design features.

Students were invited to complete a survey evaluating their experiences in the observed learning environments (see appendix 3). For each classroom, students first rated their overall satisfaction, motivation and perceived productivity on a scale from 1 (very low) to 10 (very high). These scores provide an initial indication of how students subjectively experience the physical learning environment in relation to their satisfaction, motivation and productivity.

In the second part of the survey, students assessed the presence and quality of the 16 elements across the 4 categories introduced earlier in this chapter. Each element was rated using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). This allowed for a more fine-grained analysis of how specific spatial features align with student's perceptions and needs, thereby complementing the qualitative findings from the observation phase.

Figure 4.10 provides an overview of the connection between the assessed design characteristics and the corresponding survey items, as well as their relationship to the overall scores for satisfaction, motivation, and perceived productivity. The statistical analysis of these results is discussed in paragraph 4.3.

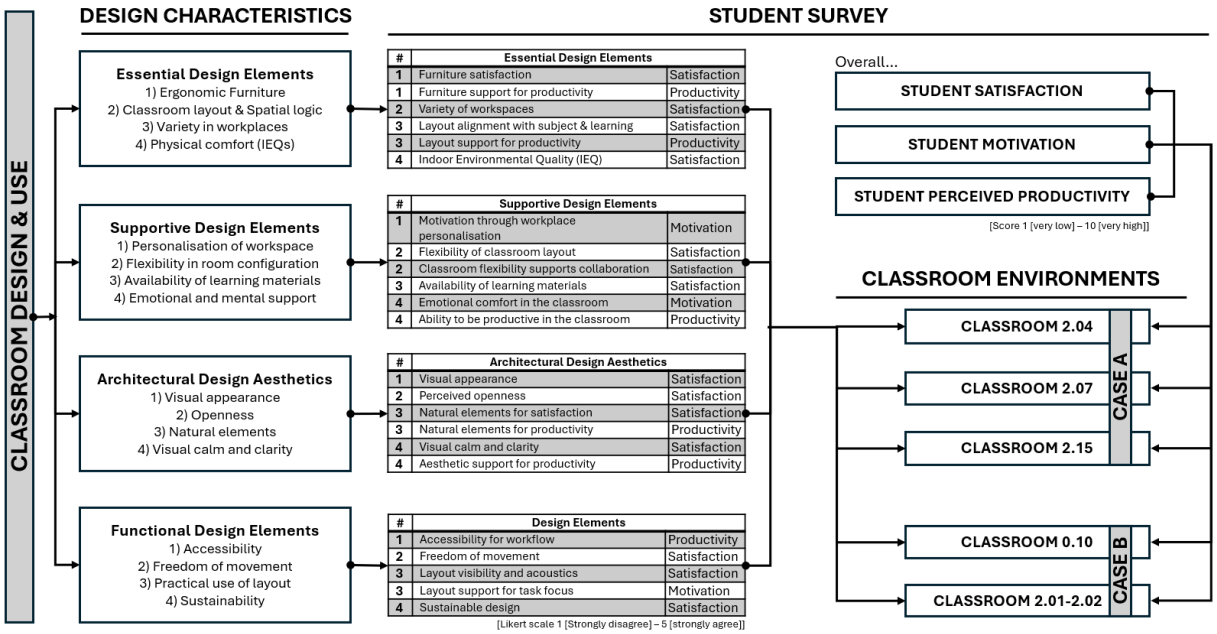


Figure 2.8 – Overview of survey items [Source: Own figure]

2.6. *Research constraints*

As with any research project, this study operates within a defined set of boundaries. These constraints ensure the research remains feasible, focused, and methodologically coherent:

Research Constraints:

1- **Scope limitation: the classroom**
The research is limited to the classroom environment in secondary education. Other spatial contexts within the school (e.g., hallways, canteens, outdoor areas) are excluded, in order to maintain focus on the most pedagogically and educational relevant setting.

2- **Cross-sectional design:**
The study captures perceptions and insights at a single moment in time. It does not include a longitudinal component, meaning that changes in satisfaction or performance over time are not measured.

3- **Sample size and generalisability:**
The number of participating schools (and students) is limited due to practical considerations (e.g., availability, school access, time constraints). The goal is to provide analytical rather than statistical generalisation, identifying meaningful patterns and themes rather than universal conclusions. The study is conducted within the context of Dutch secondary education. Differences in educational systems, cultural expectations, or classroom norms in other countries may limit the transferability of findings to international contexts.

4- **Self-reported data bias:**
The study relies on self-reported data from students, which may be influenced by temporary emotions, social desirability, or misunderstanding of the questions. These subjective perceptions provide valuable insight into student experience but may not always reflect actual behaviour or performance.

5- **Lack of direct performance data:**
Academic performance is not directly measured in this study due to ethical considerations and time constraints. As such, the study cannot draw conclusions about the causal relationship between classroom environments and measurable academic outcomes.

2.7. *Research ethics and data management*

This paragraph includes analysis and reflection on the research ethics and data management choices. The study involves sensitive information. Therefore, it's important to take the research ethics into account, which can prevent malpractice and harm towards the participants. We will look into four principles of ethics and data management. The Data Management Plan is made via the online tool offered by the TU Delft: DMPOnline. The Data Management Plan can be found in the appendix 7, the HREC in appendix 8, and the approval in appendix 9.

2.7.1. Ethics: Obligations towards research stakeholders

Principle 01: Do no harm!
The data collected from the questionnaire and interviews will be anonymized. Direct quotations from interviewees, which express personal opinions, will be carefully managed to ensure they cannot be traced back to specific individuals. Prior to storage, all data will be anonymised and securely saved on the TU Delft Project Storage. Access to the data will be restricted solely to the research team, thereby minimising the risk of compromising participants' privacy, Furthermore, any personal data that is not essential for the research will be removed from the transcripts, questionnaires, and research records.

Principle 02: Informed Consent
All participants in the interviews and questionnaires will be required to provide informed consent by signing the consent form (see appendix 10). The consent form, distributed prior to participation, contains detailed information about the research, the types of data being collected, and the procedures for handling the data. Participants must agree to the terms outlined in the consent form before proceeding with the questionnaire or interview.

At the beginning of each research activity, basic demographic questions, such as school level, and experience with the school environment, will be asked to ensure the appropriate target group is reached. All personal data will be anonymized or securely deleted after processing to protect privacy of participants. A sufficient sample size is essential to achieve statistically reliable results. Minimum sample requirements are calculated in paragraph 2.3, however, efforts will be made to include as many participants as possible to enhance the generalizability of the findings.

Participants are expected to share their opinions and experiences openly, as the research focuses on their school environment, which is unlikely to harm them or have negative consequences. On the contrary, the findings aim to provide insights that could enhance their educational environment.

The surveys will primarily consist of closed questions to ensure valid and comparable responses. However, a limited number of open-ended questions will be included to gather additional context if necessary. This approach balances data reliability with the flexibility needed for deeper understanding.

Principle 03: Quality of Data
The quality and reliability of the data collected in this research is critical to understand the relationship between classroom environment characteristics and the student learning experience. A mixed-methods approach, combining both quantitative and qualitative data, ensures a comprehensive understanding of the subject. This combination offers robust insights into the impact of classroom environment characteristics on student learning experience, as well as their perceptions of the learning environment.
Input from students, as primary users of the learning environment, is central to this study. Their perspectives provide valuable insights into the effectiveness of specific ERE features. Additionally, literature reviews form a strong theoretical foundation, offering a broader understanding of the relevant aspects of ERE and its influence on the learning experience.

As the researcher, my background and familiarity with subject provides an advantage in empathizing with the target group, particularly during the interviews and surveys. To ensure objectivity, all data collection

methods are designed to allow participants to freely express their opinions without undue influence. Structured protocols and predefined questions help minimize bias, ensuring the reliability and validity of the findings.

By integrating diverse data sources and perspectives, this research provides a well-rounded and reliable foundation for analysing the relationship between ERE characteristics and student academic performance.

Principle 04: Use of data and confidentiality
Only data that is needed to answer the research question(s) will be gathered. This data will be stored confidentially in the Project Storage of the TU Delft and personal data will be made anonymously or deleted if not essential for the research. Detailed information regarding data storage and handling is outlined in the Data Management Plan (see Appendix 7). Sensitive information, such as any disclosures of misconduct or illegal practices during interviews, will not be acted upon or included in the research without prior consultation with the TU Delft data steward. This ensures ethical compliance and proper handling of any unexpected situations.
By implementing these measures, this research upholds the confidentiality and integrity of participant data, ensuring ethical and responsible use throughout the study.

2.7.2. Data collection and storage

Before starting the questionnaire or interview all participants will receive a consent form providing detailed information about the research (see appendix 10). Participants cannot proceed with the research instrument unless they provide their explicit consent.
Only the minimum necessary personal data will be collected to create participant profiles, ensuring alignment with the target group (school level and experience with their learning environment). The questionnaires will be distributed within the selected schools.

All data collected from the research instruments will be stored securely and anonymously in the TU Delft Project Storage system. Access to data is restricted to the research team, ensuring the confidentiality and integrity of the information throughout the study. This approach ensures that data is handled ethically and responsibly, adhering to institutional data management guidelines and safeguarding participant privacy.

Personal data will not be stored or published. Only anonymous data will be made available and the generalisations that can help answer the research questions and provide insights into this topic. The participants must agree with the consent form to use their data for the research. The data will be preserved for a maximum time of 10 years.

PART II -

FOUNDATION OF THE RESEARCH

While there is no universally optimal school design, a growing amount of literature highlights the significant influence of ERE, particularly classroom environments, on student learning experience. While educational research mainly prioritised instructional quality and curriculum development over spatial design (Woolner, 2015; Hofverberg, 2025), we now see a trending shift.

Interdisciplinary research increasingly demonstrates that ERE characteristics such as spatial layout, indoor climate and functional affordance significantly shape how students engage cognitively, emotionally, and socially within the school context (Barrett et al., 2015; Kariippanon et al., 2021). These spatial features directly influence student's overall learning experience, especially in terms of their satisfaction (Dahlan, 2013; 2008), motivation (Barrett et al., 2015; Kariippanon et al., 2017), and self-perceived productivity (Appel-Meulenbroek et al., 2019; Kuok Ho, 2023).

This part delves into the theoretical foundation of this research by systematically exploring the relationship between the classroom environment, with focus on classroom design and use, and the student learning experience by using student satisfaction, motivation and productivity as a mediating role.

The structure of this part is guided by the first two sub-questions of the research and follows the conceptual model as a continuous thread. It identifies which spatial and environmental features of the classroom influence student learning experiences and establishes the design categories that will be assessed during the empirical phase of study.

By analysing these dimensions, the chapter contributes to bridging existing knowledge gaps in understanding how the classroom environment can be strategically designed and managed to improve the student learning experience. In doing so, it reinforces the importance of centring the needs and perspectives of one of the most essential stakeholders in education: the student.

Chapter 03. Foundation of the Research

3.1. Conceptual model

The conceptual model at the core of this study is built upon the premise that the classroom environment, both in its design and use, plays a significant role in shaping student's learning experiences, which can be influenced by the interplay of three key factors: *student satisfaction, student motivation,* and *student perceived productivity.* Together, they form a multidimensional construct referred to as the *student learning experience.*

Focusing solely on student satisfaction may provide an incomplete picture of the student learning experience, as it does not capture whether the environment also helps students remain productive and motivated over time. Previous studies, such as Barrett et al., (2015) demonstrate how specific classroom design features – including light, colour, and naturalness – contribute significantly to learning progress suggesting that cognitive stimulation plays a key role beyond mere satisfaction. Similarly, findings on indoor environmental qualities by Bluyssen et al., (2020) suggest that satisfaction with the environment does not necessarily translate into productivity unless the environment offers substantive support for cognitive functioning. Taken together, these studies suggests that students may feel satisfied with an environment but it still may not be sufficient to ensure motivation or productive engagement.

To address this complexity, the model proposes a more nuanced understanding of how classroom environments contribute to learning outcomes. This is guided by the following main research question: *How does the design and use of classroom environments influence the learning experience of secondary school students?*

Figure 3.1 presents the conceptual model and its corresponding variables as used in the dataset. The next section reviews literature to pose the underlying relation between the design and use of the classroom environment and the student learning experience. Rather than isolating technical performance measures, such as lighting levels or decibel readings in isolation, this study emphasis how these characteristics are interpreted and evaluated by students, making the model both academically grounded and practically meaningful.

The conceptual model organises the research thus into two layers of analysis: the classroom design and use characteristics and the student learning experience. These form the basis for the empirical analysis and are further explained in sections 3.2 and 3.3.

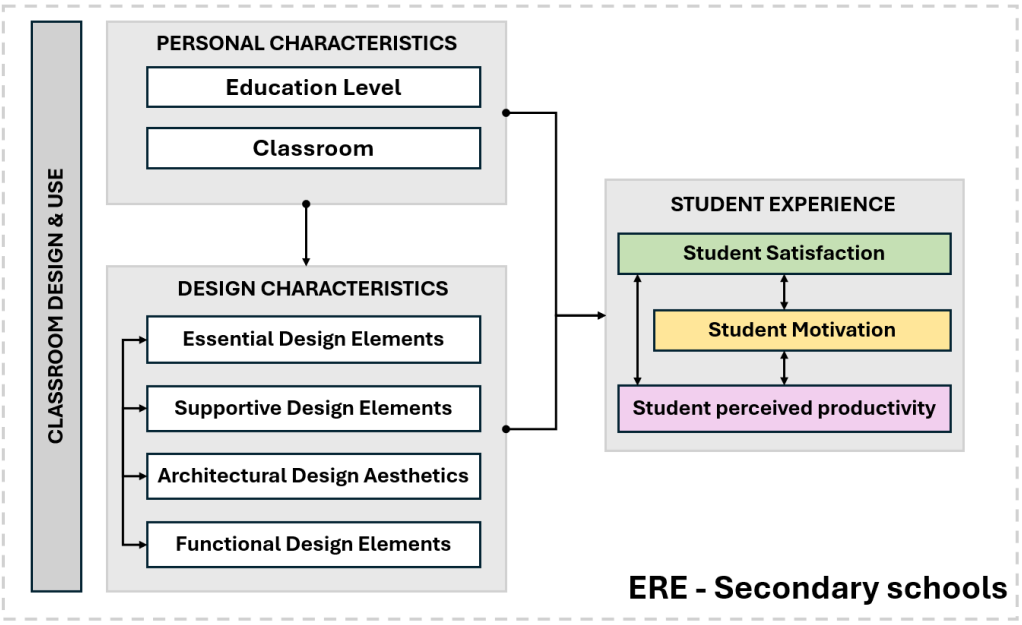


Figure 3.1 – Theoretical model: Research focus [Source: Own]

3.2. Design and use characteristics of the classroom environment

This study adopts an empirical approach to investigate how the interaction between physical features and daily use shapes the way students experience their learning environment. By combining field observations with student-reported data, this study takes a user-centred and evidence-based view of the classroom—not as a static backdrop, but as a space that actively affects how students feel, focus, and function.

Despite the growing recognition of school buildings as strategic assets, many real estate decisions in education still overlook the lived experience of students (Thomas, 2012). Strategic documents often focus on long-term investments, cost-efficiency, and sustainability, but say little about how space actually supports learning and positively impact the students learning experience (Appel-Meulenbroek et al., 2019). As Haynes (2000) already warned that without a clear understanding of how spatial environments contribute to organisational performance – in this case, education – real estate strategies risk remaining disconnected from their core mission.

At the same time, schools increasingly adopt spatial models borrowed from the corporate sector—like open-plan layouts or flexible workspaces—without questioning whether these concepts truly support teaching and learning (Palm & Staffansson-Pauli, 2020; Kariippanon et al., 2021). These generic approaches often fail to consider the specific emotional, cognitive, and behavioural needs of students, sometimes resulting in more distraction than engagement (Gislason, 2010).

To develop a more grounded and effective understanding of classroom quality, this research builds on three foundational perspectives that are commonly referenced—but not always equally applied—in school design and educational real estate planning and evaluation of educational environments, see figure 3.2:

- **The educational perspective** focuses on the content and goals of learning. It ensures that the physical environment supports curriculum delivery and instructional alignment. From this view, the classroom is not just a space to hold students, but a strategic tool to enable specific learning outcomes. If the environment does not facilitate the implementation of learning goals—such as collaboration, independent study, or digital literacy—it can undermine the very objectives it is meant to serve (Imms, Cleveland & Fisher, 2016).

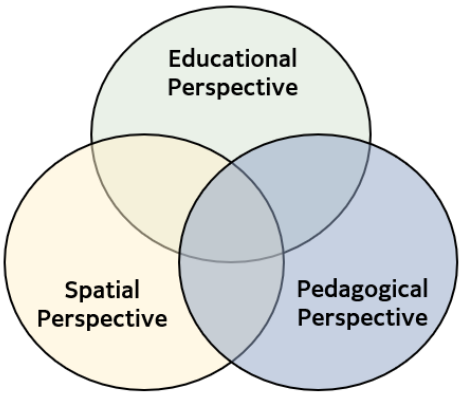


Figure 3.2 - Core elements study [Source: Own]

- **The pedagogical perspective** considers how teaching and learning unfold in practice. It highlights the importance of flexibility, variation, and inclusivity in teaching methods, and emphasises that learning spaces must adapt to different didactic strategies—ranging from direct instruction to project-based or inquiry-driven learning. This perspective brings attention to the dynamic relationship between space, teacher behaviour, and student interaction (Kariippanon et al., 2017; Hämäläinen & Vähäsantanen, 2011).

- **The spatial perspective**, which is central to this study, focuses on the physical, sensory, and architectural qualities of the classroom. It investigates how elements such as layout, indoor climate, acoustics, light, materials, and aesthetics influence students' ability to feel comfortable, stay focused, and engage with their tasks. While often underrepresented in strategic decision-making, this perspective acknowledges that space is not a neutral backdrop, but an active and experienced component of the educational process (Barrett et al., 2015; Bluyssen et al., 2020; Woolner, 2015).

When examined through the combined lens of the educational, pedagogical, and spatial perspectives, several concrete elements stand out as central to the effectiveness of the classroom environment. The three perspective are not a fixed taxonomy in existing research but reflects a synthesis of insights drawn from literature. Within this study, they serve as an analytical lens to structure the interpretation of classroom design elements, rather than as an established framework. The educational perspective directs attention to features that enable key learning outcomes such as focus, comprehension, and academic engagement. These include adequate lighting, acoustic quality, and digital infrastructure and logically layouts, which research shows are associated with improved concentration, reduced distraction, and better access to content (Barrett et al., 2015; Bluyssen et al., 2020). The pedagogical perspective emphasises the importance of spatial flexibility, furniture adaptability, and student control over aspects such as light and temperature. These elements support varied teaching strategies and promote student agency, which are linked to higher motivation and perceived autonomy and productivity in learning (Kariippanon et al., 2017; Hämäläinen & Vähäsantanen, 2011). From the spatial perspective, attention shifts to the sensory and aesthetic experience of the classroom—such as materiality, colour schemes, outdoor views, and air quality—which influence students' emotional comfort, sense of belonging, and overall satisfaction and motivation with the learning environment (Woolner, 2015; Dahlan, 2008). Together, these perspectives form a guideline and shows us that the physical design elements are not isolated variables but interact to shape the learning experience as a whole. The sixteen elements selected for this study (see Chapter 4) reflect this integrated approach.

These three perspectives are not competing frameworks but complementary layers that together shape the quality and effectiveness of learning environments. By integrating them, this research responds to a gap in current school design practices, where spatial design is too often treated as an afterthought rather than as a pedagogically and experientially informed decision domain. The spatial perspective, in particular, provides the foundation for the categorisation that follows by combining them with the output gained from the educational and pedagogical perspective. To sharpen the analytical scope and ensure methodological clarity, this study narrows its focus to one specific typology within ERE: *the classroom*. The decision is based on two core argument:

(1) *Methodological feasibility*
(2) *Pedagogical centrality*

Research into ERE is inherently broad, covering a wide array of spatial domains, from auditoriums and libraries to cafeterias, sport halls, and outdoor areas. However, recent studies emphasise the importance of narrowing the analytical focus to discrete, well-defined environments in order to yield deeper, more grounded insights. Rymarzak & Marrot (2020) argue that ERE studies benefit from focusing on specific room typologies, while Murillo-Ligorred et al. (2023) highlights that research into the interplay between learning environments and educational processes is most effective when units are spatially coherent.

The classroom meets this criterion for several reasons:

- Its layout, furniture, and technological provisions are directly observable and measurable.
- Students spend the majority of their school day in classrooms, making it the most frequently and intensively used spatial context for learning (Kariippanon et al., 2021).
- Expanding the research to include the entire school building would introduce excessive variability and complexity (an issue highlighted in the early phases of the research design, see chapter 2)

By focusing on classrooms not only ensures analytical consistency and a clearly defined scope but also allows for the generation of concrete recommendations with high practical relevance. This research treats the classroom as a micro-environment through which broader ERE themes can be understood, particularly in relation to student satisfaction, motivation, and perceived productivity. To further elaborate on this, the research can draw upon an earlier but still highly relevant framework developed by Dahlan (2008), which focuses on the components that directly influence *classroom satisfaction*, see figure 3.3.

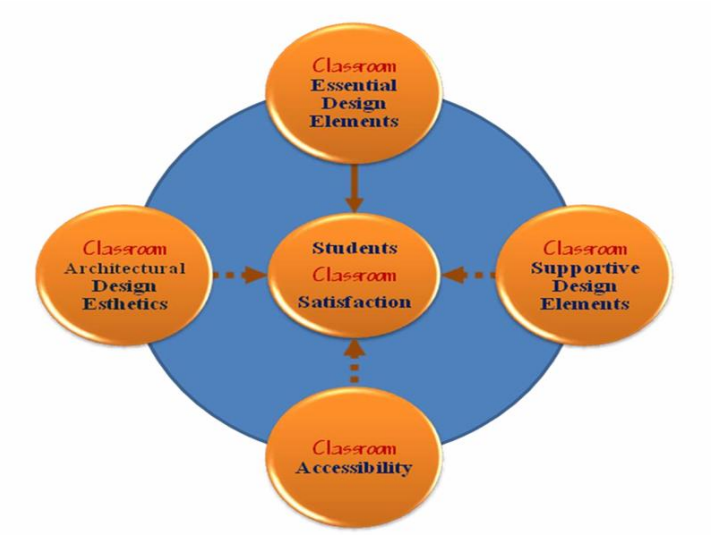


Figure 3.3 – Elements affecting student's classroom satisfaction [Source: Dahlan (2008), Page 5].

Dahlan (2008) conducted this large-scale study at King Abdulaziz University in Saudi Arabia to investigate the relationship between classroom satisfaction and academic productivity, measured via GPA. His research identified 62 classroom design elements, categorised under four main groups, which were hypothesised to predict student satisfaction, and in its turn academic outcomes (GPA), based on how students perceive their classroom environments. These design elements varied from tangible and not tangible elements and were primarily assessed through quantitative student questionnaires to score students replies about 62 different classroom design elements, categorised as follows (see table 3 till 6 in the appendix 2).

Dahlan's (2008) hypothesis – that student's academic productivity (GPA) can be positively influenced by their levels of satisfaction on their physical classroom design – was partially confirmed. Among the four design categories supportive design elements showed the most significant connection to GPA. Specifically, satisfaction with visual facilities, provision of blackboards, and artificial light were all significantly correlated with student GPA and predicted to increase the student's GPAs with 7%. According to Dahlan (2008), the other elements did not directly show significant relation with student GPA, but this didn't indicate that they are not important to students. His research underscores he relevance of user-centred design in enhancing educational environments and justify further research into optimizing learning spaces.

Despite that the research of Dahlan (2008) had some contextual differences, namely an university in Saudi Arabia, and relied mainly on GPA scores as an outcome measure, the value of his model lies in its comprehensive and structured approach to understanding how classroom design relates to classroom satisfaction and its impact on academic productivity by looking into their GPA. By categorising the design elements within a classroom into four clearly defined domains: Essential, Supportive, Accessibility, and Aesthetic, the model provides a systematic framework for analysing the multidimensional nature of the learning environment.

However, scholars such as Ma and Yang (2023) argue that satisfaction alone, as is centred in the work of Dahlan (2008), cannot fully explain learning outcomes. Emotional comfort may improve student perception, but only when it also facilitates sustained motivation and productive behaviour, that is, the ability to focus, persist, and actively participate in learning, can performance be meaningfully affected. So while Dahlan's model offers a structured and analytically useful framework and aligns with the central aim of this research: to explore how thoughtfully designed and utilized educational spaces can enhance student experience by increasing not only their satisfaction but also their motivation and productivity, its applicability to the current study is limited due to a series of contextual, pedagogical, and educational misalignments. Developed within the setting of university education in Saudi Arabia in the Middle East, the

model reflects a different pedagogical culture, architectural logic, and student demographic than the one this study engages with, namely Dutch secondary schools in 2025.

We can sum up the following differences:

1) **Mismatch in educational level and learning culture:**
   Dahlan's study focused on higher education students, who interact with educational space differently than students in secondary school. In Dutch secondary schools, students are less autonomous and more dependent on the classroom's physical and psychological support for structure, focus, and comfort (Bluyssen et al., 2020; Kuok Ho, 2023).

2) **Contextual differences:**
   The Abdulaziz university in Saudi Arabia (2002) includes culturally specific factors (e.g., proximity to prayer rooms) and technological tools (e.g., classroom DVD players) that are either outdated or irrelevant in Dutch schools. In contrast, contemporary Dutch secondary school environments emphasise student autonomy, flexibility, health, and inclusivity, priorities embedded in frameworks like *Frisse Scholen* (RVO, 2021) and current pedagogical research (Imms et al., 2016; Appel-Meulenbroek et al., 2019). Technological, social, and educational advances over the past 15 years have significantly reshaped what students expect from their learning environments.

3) **Shift in scientific understanding:**
   Where earlier models prioritised tangible physical features, current literature increasingly focus on student perception and their subjective experience of classroom design as the true mediator between space and student experience (Hanyasha et al., 2023; Kuok Ho, 2023). Many of Dahlan's elements measure technical presence rather than experiential quality. This research places greater emphasis on the perceived experience of students – *how* spatial conditions feel and function from the user perspective, rather than merely their technical or material presence.

4) **Methodological Alignment:**
   This study's methodology, based on student surveys, open responses, and classroom observations, require a model that could connect observable, relatable student experiences. Several items in Dahlan's list (e.g. 'frequency of plaint maintenance', 'signboards inside classroom') are too detailed, outdated, or not cognitively relevant to today's students.

These contextual and conceptual differences highlighted the need to update and refine the model, ensuring greater relevance to the Dutch secondary school context and better alignment with recent literature (Kuok Ho, 2023; Bluyssen et al., 2020; Kariippanon et al., 2021) emphasising student-centred and experience-driven evaluation of learning environments.

Therefore, rather than rejecting Dahlan's framework of student's classroom satisfaction, this research builds upon its strong conceptual basis but adapts it to better fit modern Western secondary school environments. In doing so, the study preserves its original strength – the recognition that spatial elements influence satisfaction, motivation and productivity – while modernising and contextualising it to ensure both empirical relevance and practical applicability. This critical assessment served as the foundation for developing a new refined model, described further in the next paragraph.

3.2.1. The updated model

Building upon the critical reflection on Dahlan's model (2008, 2013), this study introduces an updated and context-specific model that better fits the reality of Dutch secondary education in 2025. While Dahlan's framework provided an important foundation by recognising the multi-dimensional relationship between physical space and academic outcomes, it required significant adaptation to be effectively applied to a European secondary school context.

Recent studies highlight that learning environments have become significantly more dynamic and student-centred (Bluyssen et al., 2020; Kariippanon et al., 2021; Hanaysha et al., 2023). Students today interact differently with their educational spaces, valuing flexibility, comfort, personalisation, and emotional well-being alongside traditional metrics like environmental quality and resource availability. Consequently, a new model is formulated that retains the conceptual strength of the original model while enhancing its relevance and applicability to this study, see figure 3.4.

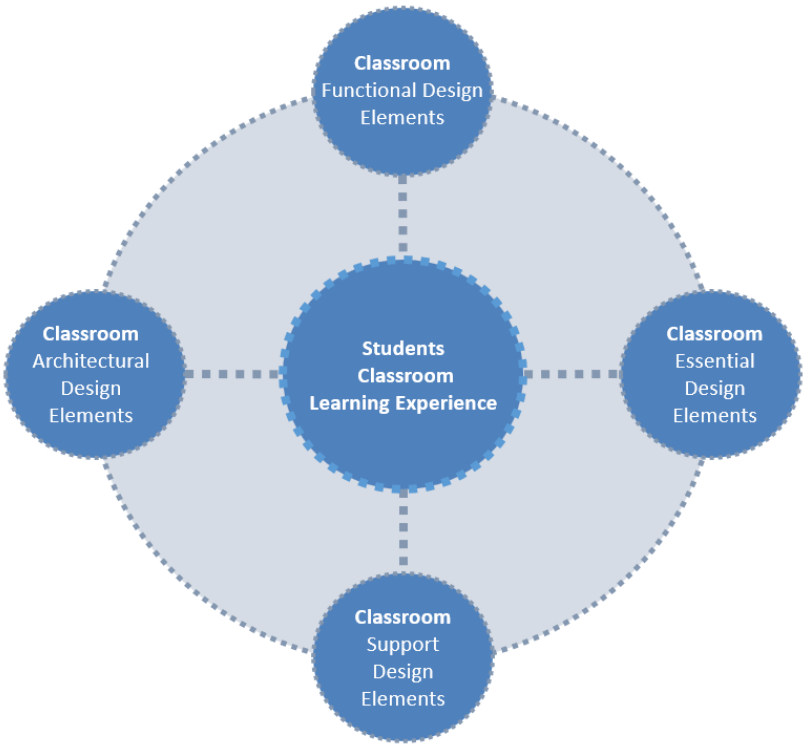


Figure 3.4 – Updated framework of the student's classroom learning experience [Source: own figure, based on Dahlan (2008)].

A detailed analysis of Dahlan's model (2008) revealed that many of the items within these categories no longer matched the spatial logic, technological standards, or nowadays educational priorities of Dutch secondary school classrooms. At the same time, recent studies emphasise that spatial features are only meaningful insofar as they are perceived, interpreted, and experienced by students (Barrett et al., 2015; Bluyssen et al., 2020; Hanaysha et al., 2023). Therefore, to apply it to this context a series of significant remodications were required, not just to modernise them, capture the cultural shifts and new educational priorities, but also to ensure the lived classroom experience of the students are assessed and not just a checklist of predefined elements.

In doing so, the categories were retained in name but updated in content by using the 3 perspectives (educational, pedagogical and spatial) as discussed before. Each dimension was refocused to capture how students perceive and emotionally experience the space, rather than merely categorising technical or infrastructural features. Where Dahlan's model (2008), emphasised the physical presence equipment (e.g.,

blackboards, projectors) and structural compliance (e.g., proximity to emergency exits), the updated model centres on qualitative spatial experiences such as comfort, flexibility, environmental control, emotional atmosphere, and navigational ease.

As explained the 3 different perspectives used in education are not competing frameworks but complementary layers that together shape the quality and effectiveness of the learning environment. Those three perspectives together demonstrate that the effectiveness of a learning environment cannot be understood solely through objective design criteria or techical standards. Instead, it must be evaluated how it is perceived and experienced by students. How those elements have impact on them (satisfaction, motivation and productivity) and are perceived by the students matters.

Especially according to those three perspectives, key spatial qualities such as cognitive comfort, environmental responsiveness due to student autonomy, and perceived usability emerge as critical factors that shape the daily learning experience. These elements go beyond form and function – they influence whether students feel supported, focused and engaged within the classroom. This approach distinguishes itself from previous studyies by treating spatial qualities not as static or predefined architectural features, but as lived and interpreted experience. It foregrounds student's subjective perceptions – how they actually feel, move, and function in the space – offering a more dynamic and human-centred understanding of classroom quality. Rather than making assumptions of the design elements, we try to formulate a framework in which we can assess and measure the impact of those elements on the students. With this approach in mind three out of the four design and use categories were redefined:

- In **classroom essential design elements**, the focus shifted from assessing physical inventories to assessing environmental qualities (e.g., thermal comfort and air quality), workspace varieties and space usage and ergonomic furniture, because studies showed that students prioritise comfort and usability over technical installations (Bluyssen et al., 2020; Kuok Ho, 2023).
- In **classroom supportive design elements,** rather than evaluating the number of technological tools, emphasis is placed on student's ability to personalise and adapt the space to different activities and needs, enhancing autonomy, engagement and emotional support as was explained (Kuok Ho, 2023; Appel – Meulenbroek, 2023; Barrett et al., 2015).
- In **classroom architectural design aesthetics,** superficial assessments of colour and finishes were expanded to include psychological and emotional aspects such as visual calmness and clarity, colour and visual appearance, natural light and elements (biophilic design), and spatial openess of the room (Kuok Ho, 2023; Sasson et al., 2021).

These elements are supported in literature, by different researchers such as Kariippanon et al. (2017) and Appel-Meulenbroek (2019), that they have a positive impact on students learning experience with focus on their social, cognitive and emotional needs (Palm & Staffansson-Pauli, 2020; Kariippanon et al., 2017; Appel-Meulenbroek et al., 2019). The remodifications in the first 3 categories are not superficial updates, but deep shifts towards a student-centred, perception-driven evaluation framework. This shift is grounded in the three earlier discussed perspectives, which collectively highlight that design evaluations must move beyond technical compliance to reflect how students actually experience and use the space in support of learning, as a few elements were already mentioned per perspective. Unlike Dahlan's model (2008), where accessibility was treated as a standalone category, this study integrates accessibility considerations into a broader categrory: **Classroom functional design elements,** as the fourth design and use category**.** This decision is based on two key arguments:

1- Contextual standards:
   In the Netherlands, basic physical accessibility (e.g., emergency exits, doorway widths, pathway widths, proximity to toilets) is legally enforced and therefore relatively uniform across secondary schools. Measuring these elements separately as a isolated category would not meaningfully differentiate student experience.
2- Broader functional purposes:
   Many features that contribute to accessibility, such as circulation, visibility, and practicality of the layout, also serve broader functional purposes that support teaching and learning.

3.2.2. Assessment of the design and use categories

As explained, to assess how the design and use of the classroom environment is perceived and experienced by students four categories were formulated: *Essential Design Elements, Supportive Design Elements, Architectural Design Aesthetics,* and *Functional Design Elements*. For each category, four elements were formulated which will be used to design the questionnaire and align observational data. These elements reflect both design features and use patterns that are known to influence student learning experience, according to literature and the 3 explained perspectives, and particularly in relation to the students learning experience: satisfaction, motivation and self-perceived productivity.
The decision to work with these four categories builds on the comprehensive framework of Dahlan (2008), who originally grouped 62 classroom design elements into four domains. In this study, his model was critically assessed and adapted to the Dutch secondary school context by integrating the three perspectives (educational, pedagogical, and spatial) and by refining the categories into a more student-centred lens, see 3.2.1. From the broad list of elements, four per category were selected as most representative, resulting in a balanced and workable set of sixteen elements. This synthesis reflects both the literature foundation and the empirical feasibility needed for the survey and observations.

The selection of the sixteen elements was based on a combined assessment of what the literature identifies as relevant and what was expected to be recognisable in the classroom context. Although some elements, such as ergonomic furniture or indoor environmental quality, may appear more objectively measurable, in this study all sixteen elements were assessed through student perceptions using the questionnaire. This approach ensured that each element was captured from the same perspective and could be analysed in a comparable way, regardless of differences in their level of tangibility.

It is important to note that these 16 elements are grounded in interdisciplinary studies as essential and frequently recurring factors (see figure 2.5) and are mentioned frequently across the three perspectives, highlighting their relevance in classroom environments, as detailed in Tables 1–4. While certain elements—such as IEQs and ergonomic furniture—have been quantitatively linked to learning-related outcomes/experiences, others have remained largely assumption-based, with limited empirical evidence about their actual influence on student's learning experiences. This study addresses this gap by moving beyond assumptions and empirically quantifying and analysing all 16 elements from the perspective of students themselves. The design and use elements are categorised as follows:

(1) **Essential Design Elements**, those elements are essential to to the core physical and environmental preconditions for learning, such as comfort, spatial organisation, and sensory quality. They are fundamental to ensuring students can concentrate and feel physically at ease within the classroom setting (Barrett et al., 2015; Bluyssen et al., 2020), see table 1:

Table 1 - Classroom Essential Design Elements [Source: own figure] Note: # stands for the 3 perspectives: educational, pedagogical and spatial, of which the elements are related from.

Nr.	Design & Use element	Description	Evidence in literature
C101	Ergonomic furniture	(Adjustable) seating and tables designed to support posture, comfort, and usability.	It was found that children showed a 'significant improvement in on-task behaviour and a marked change in seating positions following the introduction of ergonomic furniture. Studies show that ergonomic furniture can help enhance physical comfort and productivity, leading to better academic performance by 12% (Barrett et al. 2015). Poor posture can cause fatigue and distractions, negatively impacting learning outcomes. **Source:** Barrett et al., (2015); Kariippanon et al. (2017); Kuok Ho (2023).
C102	Variety in workplaces	Availability of different work settings to support different learning needs (e.g., group, solo, informal).	Allowing student to choose their work environment improves motivation and engagement by 31% (Kariippanon et al., 2017). Students report higher satisfaction when flexible work areas match task types. This supports deep learning and persistence. **Source:** Kariippanon et al. (2017); Zandvliet (2018); Appel-Meulenbroek et al. (2019)
C103	Layout & spatial logic	Arrangement of furniture and zones to support focus and movement for activities within the classroom.	Classrooms with different zones allow students to switch between activities without disrupting others. Research suggests that clear separation of quiet and active areas improves productivity and group dynamics. Research indicates that less attentive and less successful students are affected by their desk arrangement, with their productivity increasing very significantly when seated in rows. **Source:** Woolner et al. (2018); Byers et al. (2018); Barrett et al., (2015); Zhang & Barrett (2012).

C104	Physical comfort (IEQ's)	Thermal comfort, air quality, noise levels, and daylight (IEQ-standards).	Research indicates that thermal comfort and fresh air have a strong impact on productivity and satisfaction. Poor IEQ leads to headaches, drowsiness, and stress, while fresh and stable climates promote productivity and motivation. led to a 25% increase in cognitive errors and a 20% drop in reading comprehension among students (Bluyssen e al., 2020). **Source:** Bluyssen et al. (2020); Barrett et al. (2015)

(2) **Supportive Design Elements** allow students to personalise and adapt the space, which fosters autonomy, emotional connection, and engagement, as is supported through the pedagogical perspective within education. These features reflect a shift towards flexibility and user-centred environments (Deci & Ryan, 2000; Appel-Meulenbroek et al., 2019), see table 2:

Table 2 - Classroom Supportive Design Elements [Source: own figure] Note: # stands for the 3 perspectives: educational, pedagogical and spatial, of which the elements are related from.

Nr.	Design & Use element	Description	Evidence in literature
C201	Personalisation of workspace	Ability of students to adapt or personalise their learning environment (e.g. preferred seating, workspace layout).	Allowing student to personalise their learning spaces increases their sense of satisfaction, motivation and productivity. These factors are critical for active learning and sustained engagement. **Sources:** Deci & Ryan (2000); Niemiec & Ryan (2009).
C202	Flexibility in room configuration	How easily the classroom can be rearranged to fit different activities by using moveable furniture and reconfigurable layouts for different activities(e.g., group work, solo study, project zones).	Classrooms that are flexible to rearrange learning setups support student participation, motivation, satisfaction, and learning efficiency. Flexibility also prevents cognitive fatigue. **Sources:** Gislason (2010); Kariippanon et al. (2017); Imms et al. (2016).
C203	Availability of learning materials	The availability and accessibility of learning materials (e.g., books, whiteboards, digital tools).	Easy access to resources promotes learning independence, reduces reliance on teacher assistance and encourages productivity and effective learning routines. **Sources:** Zandvliet (2018); Van der Hoeven et al., (2022).
C204	Emotional and mental support	Design features that support calm, safety, and emotional well-being.	Emotionally supportive environments help reduce overstimulation and foster psychological safety, allowing students to perform and produce better. **Sources:** OECD (2017); Gislason (2010).

(3) **Architectural Design Aesthetics** includes elements that shape the visual and emotional tone of the classroom. These factors, while often overlooked, can influence student's sense of belonging, calmess and focus, as was emphasised in the pedagogical and spatial perspective (Lippman, 2010; Sasson et al., 2021), see table 3:

Table 3 - Classroom Aesthetics Design Elements [Source: own figure] Note: # stands for the 3 perspectives: educational, pedagogical and spatial, of which the elements are related from.

Nr.	Design & Use element	Description	Evidence in literature
C301	Visual appearance	Visually engaging classrooms e.g. colours, materials, décor and design coherence.	Visually pleasing classrooms positively affect student attitude, increase motivation, satisfaction, emotional connection, and willingness to engage and perform. **Sources:** Lippman (2010); Barrett et al. (2015)
C302	Openness	Perceived spaciousness and transparency (e.g., open layouts, visibility across space) enhance orientation and emotional comfort.	Open spaces reduce stress and enhance productivity by improving clarity and behavioural flow. **Sources:** Gislason (2010); Byers et al. (2018)
C303	Natural elements	Integration of daylight, greenery, or natural textures (biophilic design).	Natural features support psychological satisfaction, boost motivation, and enhance perceived productivity. It reduces stress and stimulates personal well-being. **Sources:** Barrett et al. (2015); OECD (2017)
C304	Visual calm and clarity	Visual order, simplicity, and reduced clutter create a clean and distraction-free environment.	Visually calm environments reduce overstimulation, support memory retention, and improve productivity. **Sources:** Fisher (2005); Gislason (2010)

(4) **Functional Design Elements** reflect how the classroom supports student activity and movement. These determine how easily students can access resources, transition between tasks, and maintain productive learning behaviour as is the main focus of the spatial perspective, (OECD, 2017; Van der Hoeven et al., 2022), see table 4:

Table 4 - Classroom Functional Design Elements [Source: own figure] Note: # stands for the 3 perspectives: educational, pedagogical and spatial, of which the elements are related from.

Nr.	Design & Use element	Description	Evidence in literature
C401	Accessibility	Refers to how easily students can access learning zones, materials, and move within the classroom without obstruction.	Better spatial accessibility reduces interruptions and improves behavioural flow and perceived productivity. **Sources:** Gislason (2010); Van der Hoeven et al. (2022)
C402	Freedom of movement	The ease with which students transition between activities or work modes (e.g., group ↔ solo work) and move around without crowding or congestion.	Classrooms that support unrestrained movement lead to less disruption, more motivation, and improved cognitive clarity. **Sources:** Barrett et al. (2015); OECD (2017)
C403	Practical use of layout	How the physical organisation and logic of spatial zoning supports the intended educational flow and structured behaviour.	Logical layouts support lesson structure, teacher guidance, and predictable classroom routines. **Sources:** Van der Hoeven et al. (2022); Imms et al. (2019)
C404	Sustainability	Resource-efficient design and visible cues for environmental care by students.	Students value and feel motivated in sustainable environments, which positively affects their behaviour and productivity. **Sources:** OECD (2017); Woolner (2010)

Based on the findings from paragraph 3.2, the conceptual mode is further refined to identify the 16 design and use elements of classroom environments. These insights provide a structured response to the first sub-question by clarifying which spatial and functional classroom characteristics – derived from literature – are most likely to influence student's learning experiences, see figure 3.5.

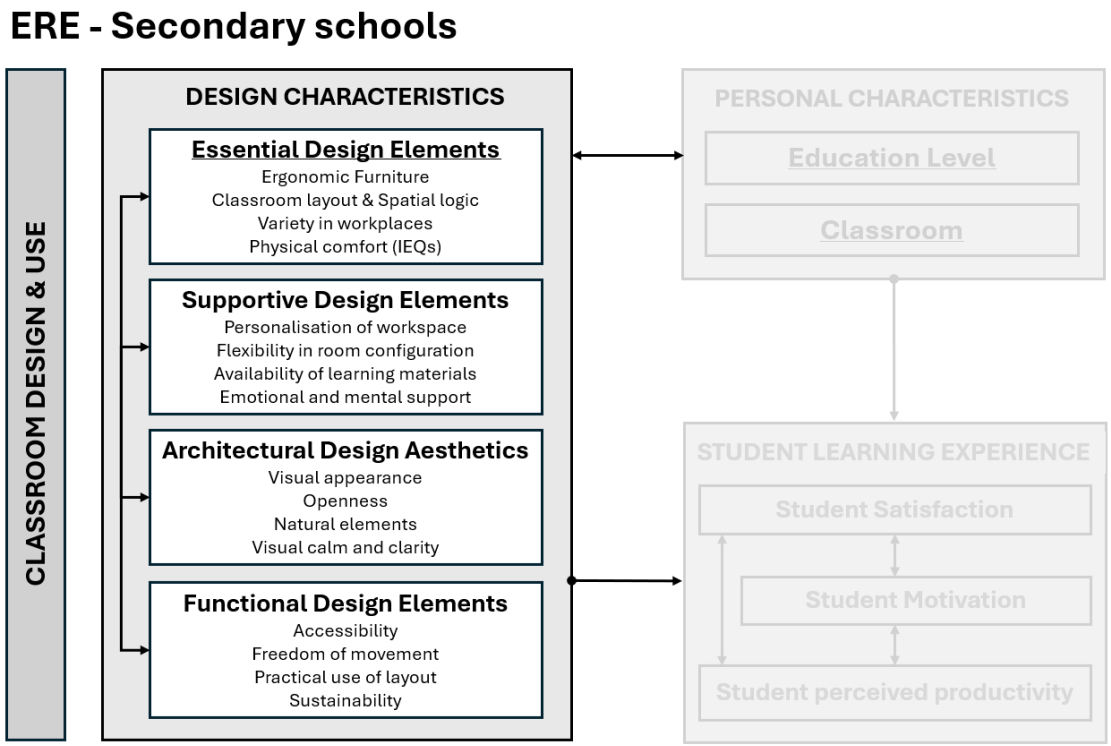
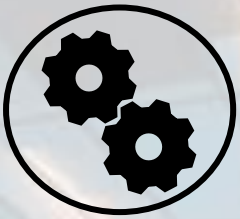


Figure 3.5 – Updated conceptual model: 'design characteristics' [Source: own figure].

RESEARCH THEMES:
Summary Updated Design & Use Categories



CLASSROOM ESSENTIAL DESIGN ELEMENTS

This category includes core physical conditions such as comfortable furniture, indoor climate, spatial layout, and variety in workplaces – all of which are essential for creating an effective learning environment. These elements are typically preconditions for comfort and concentration, and their absence is often directly linked to dissatisfaction or distraction. These aspects align with research that highlights how discomfort, poor air quality, or inappropriate furniture can lead to reduced task focus and increased cognitive fatigue (Barrett et al., 2015; Bluyssen et al., 2020).

- ***Ergonomic furniture, classroom layout & spatial logic, variety in workplaces and environmental indoor climate.***

CLASSROOM SUPPORT DESIGN ELEMENTS

Supportive elements go beyond the basics and refer to the functional enrichment and adaptability of the classroom. They allow students to personalise their learning experience and adapt the space according to different learning activities and preferences. These features have been shown to support a sense of ownership, autonomy, and engagement among students—critical factors for motivation and satisfaction (Deci & Ryan, 2000; Kariippanon et al., 2017).

- ***Personalisation of workspace, flexibility in room configuration, availability of learning materials, and emotional and mental support.***

CLASSROOM ARCHITECTURAL DESIGN ESTHETICS

This dimension addresses the visual and emotional experience of the space. Aesthetics are often underestimated in their educational impact, yet they shape how student feel upon entering a classroom and whether the space invites focus, calm, and a sense of belonging. Studies show that aesthetic factors such as colour schemes, daylight integration, and presence of natural elements have effect on emotional well-being, cognitive clarity, and even classroom behaviour (Lippman, 2010; Gislason, 2010). It can either support or hinder learning focus and emotional regulation (Barrett et al., 2015).

- ***Visual appearance, openness, natural elements, visual calm and clarity.***

CLASSROOM FUNCTIONAL DESIGN ELEMENTS

This category brings together aspects related to how the space actually supports daily activity, particularly in terms of movement, transitions, lesson flow and sustainable use. It reflects the operational logic of the classroom: how easily students navigate, access resources, and maintain behavioural flow during activities. Good functional design increases perceived predictability, comfort, and focus (Van der Hoeven et al., 2022; OECD, 2017).

- ***Accessibility, freedom of movement, practical use of layout, and sustainability.***

3.3. Student learning experience in the classroom environment

To gain meaningful insights into how classroom environments support or hinder learning, this study moves beyond technical design evaluation to focus on student perception. The guiding sub-question for this section is: *Which indicators are suitable for measuring the student learning experience in relation to classroom design and use?*

When designing and managing ERE, and more specifically the learning environment, it is essential to understand the perspective of the primary users, namely the students. Yet, the student perspective in relation to the spatial experience remain underrepresented in academic literature (Thomas, 2012). Given the fact that students interact with learning spaces daily, their experiences provide valuable insights into how spatial and functional characteristics impact their engagement, satisfaction, and even performance (Kariippanon et al., 2017; Thomas, 2012; Bluyssen et al., 2020). Therefore, to bridge this gap, it is important to analyse how students perceive, interpret, and use educational spaces and how we can measure their learning experience. This study positions the student´s learning experience as a central dimension in evaluating classroom environments, moving beyond architectural assumptions and technical metrics.

3.3.1. The Student Perspective

As Leaman (2002) already emphasised that buildings are more than physical structures; they are complex systems that influence and are influenced by the activities, preferences and needs of their users. Students do not passively inhabit educational spaces, they actively engage with them through movement, interaction, collaboration, and concentration (Kariippanon et al., 2020). A student-centred design approach, therefore, is not just a pedagogical ideal but a strategic necessity. Studies show that schools incorporating user feedback in the design and management of learning environments achieve higher levels of student satisfaction, motivation, and engagement (Kuok Ho, 2023; Woolner, 2018; Kariippanon et al., 2020).

As was noted in paragraph 3.2, Integrating the student perspective allows for spaces that better accommodate diverse learning styles and create a sense of ownership and autonomy (Kuok Ho, 2023; Woolner, 2018). Flexible classrooms that offer choice, adaptability, and comfort have been found to significantly increase collaboration and engagement (Byers et al., 2014; Sasson et al., 2021). Conversely, neglecting student input often results in learning environments that meet functional standards but fail to support the actual needs of their users (Thomas, 2012).

To evaluate how design and use of the classroom environment impacts learning, this research defines the student learning experience as a multidimensional construct. It is not captured by a single factor such as enjoyment or functionality, but it is shaped through a combination of emotional, behavioural, and cognitive responses (Barrett et al., 2015; Kariippanon et al., 2017; Bluyssen et al., 2020), which emphasises that it must not be measured by only one lens.

For this study, the personal characteristics of the students were limited to *educational level* and *classrooms* due to ethical considerations (as explained in chapter 2) and analytical relevance. The educational level is considered as the primary demographic indicator, while data on gender and exact age were deliberately excluded.

Although gender differences are frequently discussed in educational research, their relevance is largely domain-specific rather than general. Studies consistently show variation in performance and participation between boys and girls, particularly in subject such as mathematics and reading. However, these differences do not consistently extend to broader outcomes such as satisfaction, motivation, or self-perceived productivity (Wang & Degol, 2017; Shamaki, 2015). Second, recent studies indicate that differences in how students perceive classroom environments are typically small and inconsistent, especially when compared to stronger predictors such as personality traits, socio-economic background, or teacher-student interaction (Yang et al., 2021). Similarly, Dahlan (2008; 2013) found that although gender distinctions were made, the differences in mean ratings between male and female students were marginal (≈0.1–0.2 points). This suggests that while gender can produce minor variations, its overall influence on classroom experience remains limited. Third, reducing unnecessary demographic questions also aligns

with ethical and privacy considerations, helping to safeguard student anonymity while keeping the focus on meaningful variation. For these reasons, gender was not included in the dataset, though its potential relevance will be critically revisited in the discussion section.

The same reasoning applies to age, which was not collected separately. Since the study specifically targeted students from 4 HAVO, 4 VWO, and 5 VWO, the entire sample falls within the age range of 16–18 years. This focus was also an ethical requirement (see Chapter 2), ensuring the inclusion of only students aged 16 and older. As the variation within this range does not exceed one to two years, classroom year is considered a sufficient and reliable proxy for developmental stage. By limiting personal characteristics to classroom year and educational level, the study maintains methodological clarity and ethical responsibility, while still capturing the most relevant variation in how students engage with their learning environments (see Figure 3.6).

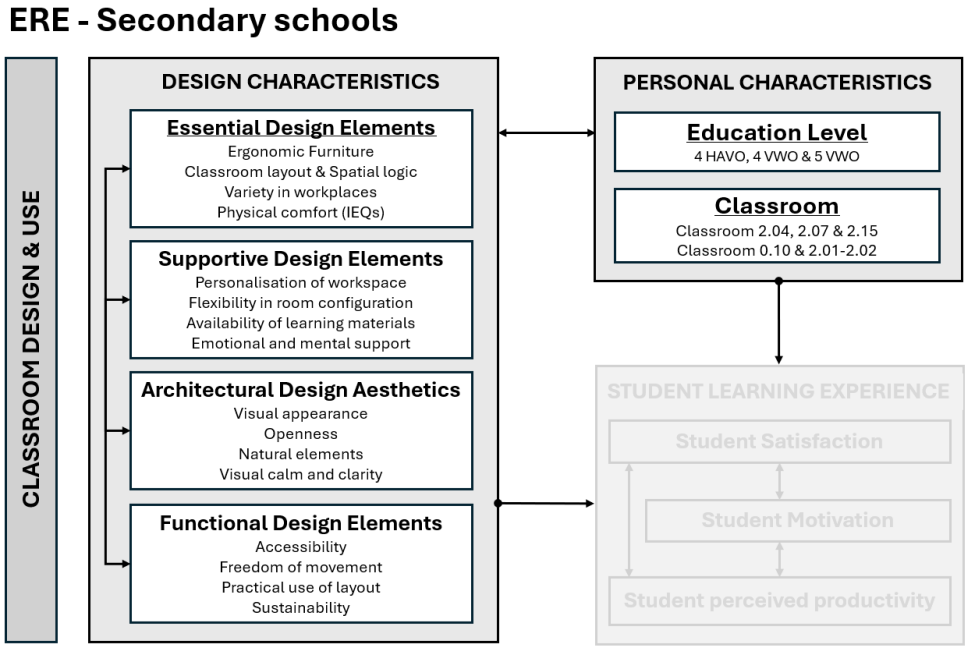


Figure 3.6 – Updated conceptual model: 'personal characteristics' [Source: own figure]

3.3.2. Mediating relationship within student learning experience

While the student learning experience is often assessed using a single measure—typically satisfaction—recent research emphasises that a more nuanced and multi-dimensional approach is necessary (Barrett et al., 2015; Kariippanon et al., 2020). Therefore, we integrate student satisfaction, motivation, and self-perceived productivity as three distinct but interrelated indicators that together capture the emotional, behavioural, and functional dimensions of how students engage with their classroom environment.
Several empirical studies support the importance of examining these indicators in conjunction rather than isolation. or instance, Barrett et al. (2015), in a large-scale study involving 153 classrooms across 27 UK schools, found that specific design elements—such as lighting, colour, and layout flexibility—could enhance learning outcomes by up to 17%. While this study used standardised test scores as an outcome measure, its environmental audits revealed that improvements in comfort, personalisation and stimulation were crucial for mediating variables. These factors closely align with satisfaction *and motivation*, reinforcing the need to consider both emotional and behavioural responses to spatial design.

Similarly, A large-scale study in Australia conducted by Kariippanon et al. (2017), found that students in flexible learning environments reported significantly higher engagement by 31% and better collaboration among students by respectively 25% compared to traditional settings. Furthermore, Bluyssen et al. (2020) observed that classrooms with poor indoor environmental quality led to 25% more cognitive errors and a 20% decrease in reading comprehension, even when satisfaction levels were not explicitly low. These

studies suggest that motivation and productivity are not simply extensions of satisfaction, but critical and measurable dimensions in their own right.

Moreover, Ma and Yang (2023) argue that satisfaction alone cannot explain academic behaviours such as persistence or focus. Emotional comfort may improve perception, only if simultaneously fosters motivation and productive behaviour, such as functional task execution and focus and active engagement. A student may feel satisfied with a space yet remain unmotivated or unfocused if the environment lacks functional support or fails to stimulate the user (Barrett et al., 2015).

To effectively measure how students experience their classrooms, this study defines the student learning experience as a multidimensional construct consisting of three core indicators: *student satisfaction, student motivation, and student self-perceived productivity.* Together, these indicators reflect how students feel, behave, and perform within the classroom setting:

(1) ***Student satisfaction*** *captures emotional comfort and perceived support – whether the space feels calm, pleasant, and suitable for learning (Zandvliet, 2018; Hanaysha et al., 2023).*
(2) ***Student motivation*** *refers to the willingness to participate, engage, and persist with learning tasks, and is influenced by spatial affordances like flexibility, autonomy, and stimulation (Deci & Ryan, 2000; Kariippanon et al., 2017).*
(3) ***Student self-perceived productivity*** *refers to how well students believe the environment supports their ability to focus, complete tasks, and learn efficiently (Kuok Ho, 2023; Appel-Meulenbroek et al., 2019).*

These findings collectively support the view that student satisfaction, motivation, and self-perceived productivity are three interrelated yet distinct dimensions that together provide a richer and more accurate framework for understanding how classroom environments are experienced by students. Each represents a unique form of student response: satisfaction reflects how the space is felt, motivation reflects how it stimulates and inspires participation, and productivity captures how it supports task performance.

By integrating all three indicators, this research avoids oversimplifying student experience to a single measure and instead builds a more nuanced framework for evaluating classroom effectiveness from a user-centred perspective. These three indicators function as mediating constructs—interpretive filters through which students evaluate spatial and functional characteristics.

Figure 3.7 presents the conceptual model, which incorporates these mediators and operationalises them as variables within the dataset to empirically assess how classroom design and use affect the student learning experience.

INDICATORS OF STUDENT LEARNING EXPERIENCE:
Summary of the three indicators

This study shifts focus from technical design metrics to how students perceive and experience classroom environments. As the primary users, student engage with the space emotionally, behaviourally, and cognitively. Their perspective is crucial in evaluating whether classroom environments support or hinder learning (Thomas, 2012; Kariippanon et al., 2017). Student learning experience is not a one-dimensional concept. It must be measured through multiple interrelated indicators to understand how design and use impact learning outcomes.

Based on the literature, this study identifies three core indicators that will be used in the empirical research:

STUDENT SATISFACTION:

Reflects students' emotional comfort and perceived support within the classroom environment. A satisfied student feels that the space is calm, pleasant, and appropriate for learning activities. Environmental factors such as light, temperature, layout, and décor contribute significantly to this emotional perception. Focusing on how it feels.

*(emotionally). *Key sources: Dahlan (2008; 2012); Hanaysha et al. (2023)*

STUDENT MOTIVATION:

Refers to the willingness to participate, persist, and engage in learning tasks. Motivation is driven by spatial features such as autonomy, adaptability, and stimulation. Classrooms that allow flexibility and offer control to students promote higher intrinsic motivation and learning engagement. Focusing on how it inspires action and stimulates participation.

*(behaviourally). *Key sources: Barrett et al. (2015); Kariippanon et al. (2017)*

STUDENT SELF-PERCEIVED PRODUCTIVITY:

Captures how well students feel the classroom supports their ability to concentrate, complete tasks, and learn effectively. This includes perceived cognitive performance, task focus, and energy. It reflects whether students feel they are achieving their academic potential in a given space. Focusing on how it supports performance.

*(Cognitively). Key sources: Kuok Ho (2023); Appel-Meulenbroek et al. (2019)

3.4. SUMMARY CHAPTER 03

Chapter 03 explored how the classroom environment can be meaningfully analysed from the student perspective, and how this perspective informs both the selection of spatial features and the evaluation of the student learning experience. This chapter tried to formulate an answer to the first two sub-questions, as will be summarised in the next section.

Sub question 01 – *Which design and use aspects, identified through literature, contribute to a classroom environment that supports student learning experiences?*

To answer this sub-question, the existing framework of Dahlan (2008) was critically analysed and modified to align with the current scope of this study. In summary, the remodifications result in a model that shifts:

- From physical presence to perceived experience
- From outdated equipment lists to nowadays spatial qualities
- From regulatory compliance to emotional and functional coherence
- From separated accessibility to integrated functionality

These refinements led to the development of four categories to classify and assess the design and use of classrooms:

1) **Essential Design Elements** (e.g., ergonomic furniture, layout, and workspace variety, and IEQs)
2) **Supportive Design Elements** (e.g., autonomy, emotional support, flexibility and learning materials)
3) **Architectural Design Aesthetics** (e.g., visual clarity, natural elements, openness and aesthetics)
4) **Functional Design Elements** (e.g., accessibility, circulation, practical use, and sustainability)

These categories, and the 16 elements, emerged from interdisciplinary literature – spanning the three perspectives: educational, pedagogical and spatial - and were refined through the lens of three key student-centred indicators: satisfaction, motivation, and self-perceived productivity.

In total, 16 frequently recurring and research-supported elements were identified. These form the analytical basis for assessing how classroom design and use elements contribute to the student learning experience. These were visualised in the conceptual framework shown earlier (Figure 3.6).

Sub question 02 - *Which indicators are suitable for measuring the student learning experience in relation to classroom design and use?*

This study argues that the student learning experience is a multidimensional concept that should not be measured through satisfaction alone, as is measured in many studies. Instead, it integrates three interrelated indicators:

- **Student satisfaction**: Reflects students' emotional comfort and perceived support within the classroom environment.
- **Student motivation**: Refers to the willingness to participate, persist, and engage in learning tasks.
- **Student self-perceived productivity**: Refers to the functional assessment of how the environment supports task completion, focus, and performance.

Researchers argue that satisfaction alone cannot explain academic behaviours such as persistence or focus. Emotional comfort may improve perception, only if simultaneously fosters motivation and productive behaviour, such as functional task execution and focus and active engagement. A student may feel satisfied with a space yet remain unmotivated or unfocused if the environment lacks functional support or fails to stimulate the user (Barrett et al., 2015; Kariippanon et al., 2017).

These indicators reflect emotional, behavioural, and cognitive responses to space and have been validated in previous studies (e.g., Barrett et al., 2015; Kariippanon et al., 2021). Together, they provide a more complete framework and accurate evaluation of how students interact with and are affected by the learning environment.

THE FINAL CONCEPTUAL MODEL

The final conceptual model (figure 3.7) synthesises the outcomes of both sub-question by integrating:

- The four design and use categories, with 16 measurable spatial elements, and
- The three mediators of student learning experience, as key indicators to assess how those elements are perceived by the students.

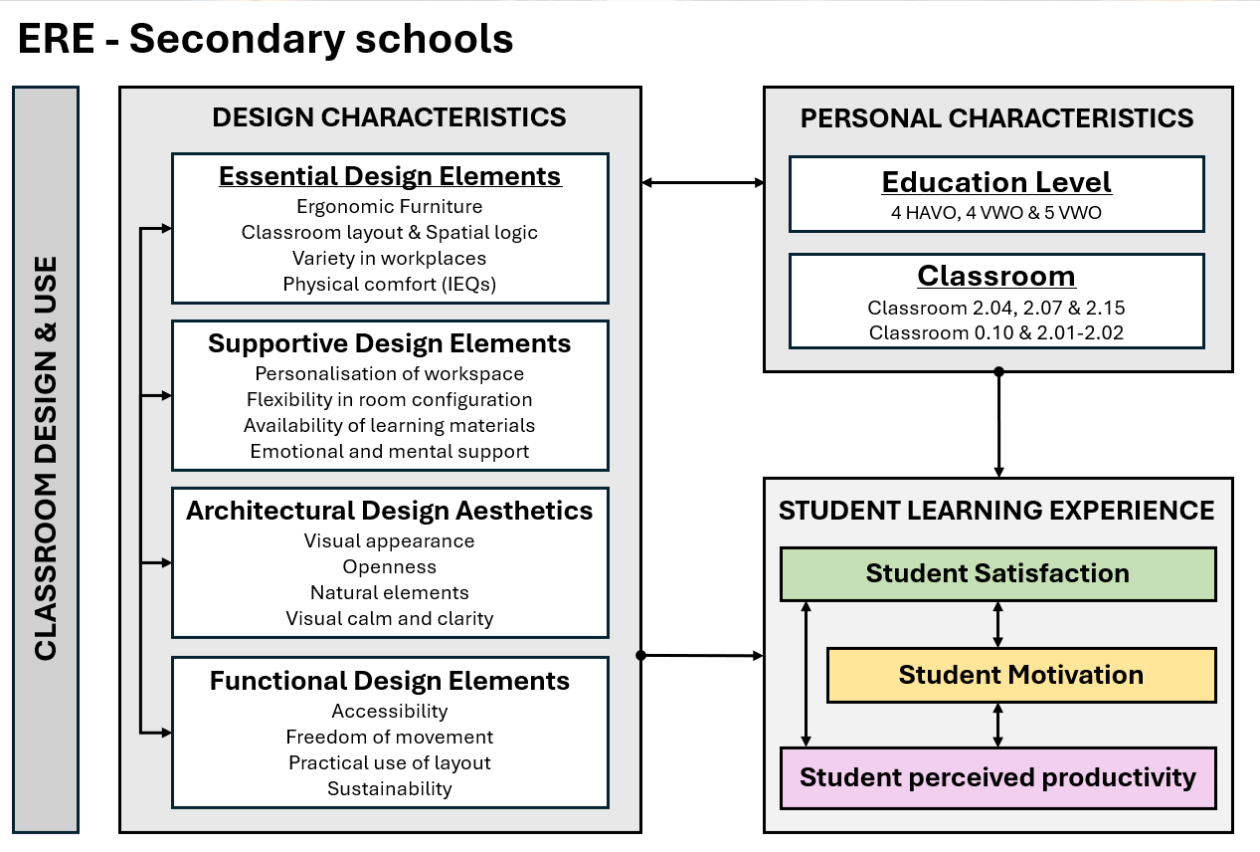


Figure 3.7 – Theoretical model [Source: Own]

This model (Figure 3.7) provides the theoretical and empirical foundation of the data variables for the research methodology in Chapter 5, enabling a two-layered analysis that links observable spatial qualities to subjective user outcomes. It allows for analysing not only which environmental features matter, but how they are experienced by the students themselves.

PART III -

RESULTS

Chapter 04. Results

This chapter presents the empirical results derived from the case studies and survey data. This research design employed a mixed-methods approach in which the student survey served as the primary instrument for data collection, supported by complementary classroom observations and floorplan analysis (see appendix 6) and teacher interviews (see appendix 4). While the survey formed the quantitative core, triangulation with qualitative insights helped contextualise the findings within actual classroom dynamics.

The empirical case study was conduced at two Dutch secondary schools, selected according to predefined case selection criteria (see paragraph 2.5). Two schools with diverse spatial conditions were selected, allowing for comparative analysis of student perceptions across different classroom settings:

- Case A: School A – a newly constructed secondary school in Schiedam. This school features more traditional classroom layouts and design elements. Three classrooms were selected for in-depth analysis based on their use and design.
- Case B: School B – a contrasting context featuring recently renovated classrooms designed for flexibility and collaboration. Two classrooms were selected based on their adaptive layouts and varied functional design features.

A total sample size of n=173 was obtained, distributed across two Dutch secondary schools and five classrooms. Table 5 provides the frequency of the personal characteristics of the sample. The personal characteristics are limited to classrooms and school levels of the students as is explained in chapter 2. Statistically significant but small differences between the samples were found for school levels per classroom. This difference can be attributed to the fact that certain educational levels are either underrepresented or entirely absent in some classrooms, as illustrated in table 5. This absence or underrepresentation is due to the fact that these levels do not receive instruction in those specific classrooms, which was one of the prerequisites for student participation in the survey.

Table 5 – Frequency of personal characteristics [Source: own figure]

Personal characteristics	*Classroom*	*Level*	*Frequency*	*Total sample size*	*Response rate(%)*	*Total response rate (%)*	*Total sample (N=173)*
School A	2.04	4 HAVO	40 (57)				
		4 VWO	0 (0)	40 (57)	70%		
		5 VWO	0 (0)				
	2.07	4 HAVO	12 (24)				
		4 VWO	12 (22)	36 (68)	53%	66%	63.6%
		5 VWO	12 (22)				
	2.15	4 HAVO	0 (0)				
		4 VWO	18 (20)	34 (42)	81%		
		5 VWO	16 (22)				
School B	0.10	4 HAVO	22 (25)				
		4 VWO	03 (20)	48 (70)	69%		
		5 VWO	23 (25)				
	2.01-2.02	4 HAVO	10 (25)			55%	36.4%
		4 VWO	05 (20)	15 (45)	33%		
		5 VWO	0 (0)				

The internal validity of the data variables was assessed using Cronbach's alpha and inter-item correlations, see table 6. All constructs demonstrated sufficient internal consistency to indicate that the items can be reliably used together as a single construct. As explained in chapter 02, the three mediators: *satisfaction, motivation and self-perceived productivity*, showed excellent reliability, with a Cronbach's alpha of 0.90. Likewise, the design and use elements of the four categories *(Essential, Supportive, Architectural and Functional design elements)* also displayed strong reliability, with alpha values ranging from 0.82 to 0.84 and an inter-item correlation ranging from 0.55-0.62. These results confirm the internal coherence of the data variables and indicates that the survey constructs are statistically reliable. The *supportive design*

elements achieved in general the highest mean score (M=7.0), indicating that students generally perceived these aspects most favourably. In contrast, *essential design elements* scored slightly lower (M= 6.3), indicating comparatively fewer positive evaluations in that category in comparison to the other categories. The standard deviation (SD) values indicate the degree of variability in responses: lower SDs reflect greater consensus among students, whereas higher SDs suggest more diverse perceptions. In this study, SD values ranged from 1.8-2.2, pointing to a moderate spread in opinions and indicating that the aspects were relatively consistent across the sample (N=173).

Table 6 – Intern validity of multi-item scale variables [Source: own figure]

Label (N=173)	*# of items*	*Cronbach's alpha (α)*	*Inter-item correlation*	*Mean*	*Standard Deviation (SD)*
Mediators	3	0.90	0.81	6.7	2.2
Essential Design Elements	4	0.83	0.62	6.3	2.2
Supportive Design Elements	4	0.82	0.55	7.0	1.8
Architectural Design Aesthetics	4	0.84	0.58	6.9	1.8
Functional Design Elements	4	0.84	0.57	6.6	1.9

When these differences are considered alongside the four broader design categories, the relatively low variation in mean scores between categories (M = 6.3–7.0) and the modest spread within categories (SD ≈ 1.8–2.2) suggest that students value each dimension of classroom design in a relatively balanced way. Higher SDs in some groups may reflect differences in class composition (see paragraph 4.3.3. table 15-16), or individual preferences, rather than the inherent importance of the design category itself.

4.1. Observation Case studies

The first case study is conducted at School A, it is characterised by a future-oriented but teacher-centred educational approach, see table 7 for school profile. Its mission combines a solid academic curriculum with progressive pedagogical practices that focus on active student participation and transferable skill development.

Table 7 – School profile School A [Source: own figure]

School	**School A, Schiedam**
Building year	2013
Design principle	Cradle to cradle (C2C) & circular, sustainable design.
Educational tracks	HAVO & VWO
Students	± 700 students (ages 12-19)
Surface area	± 6150 m^2 gross floor area
Location	Schiedam
SES-Context	Relatively low-middle socio-economic status with divers student population
Keywords observation	Traditional education, Teacher-centred classrooms.

For this case study, three classrooms were selected for in-depth observation and analysis: *classroom 2.04, classroom 2.07,* and *classroom 2.04* (see table 8). The selection was based on spatial diversity within the school building, such as furniture, size, position and subject, allowing for an internal comparison of different classroom environments under similar institutional conditions.

Table 8 – Classroom profiles profile school A [Source: Own].

Classroom	**Subject**	**Size**	**Capacity**	**M2 / student**	**Furniture & layout**
2.04	Dutch Language	8.8m x 7.4m	28-30 students	28 students: 2.3 m2/ student 30 students: 2.2 m2/ student	Traditional rows, standard desk and chairs
2.07	Dutch Language	7.5m x 7.m	28-30 students	28 students: 2.0 m2/ student 30 students: 1.9 m2/ student	Traditional rows, standard desks and chairs (tighter layout)
2.15	Physics	10.1m x 7.5m	28-30 students	28 students: 2.7 m2/ student 30 students: 2.5 m2/ student	More collaborative layout but still teacher centred. Possibility for zoning

School A's vision is shaped by two core perspectives:

- From an educational perspective, the school aims to equip students with a strong academic foundation, while fostering critical thinking, self-direction, and social responsibility. These aims are pursued through interdisciplinary learning formats and an explicit emphasis on 21st-century skills.
- From a pedagogical perspective, the school promotes a safe, inclusive, and responsive learning environment. Teachers adopt differentiated instruction, provide formative feedback, and encourage goal-oriented reflection, aiming to develop reflective and independent learners.

The three observed classrooms revealed varying levels of alignment with these values. Classroom 2.07 featured a static traditional layout, which supported frontal teaching but limited adaptability as was strived for within the pedagogical perspective. Classroom 2.04 and 2.15 where in comparison more flexible in both size and furniture arrangement, as will be explained further on in the paragraph, supporting a wider range of didactic formats and smoother transitions between activities. In particular, classroom 2.15 facilitated informal collaboration and peer interaction, by integrating group tables, which better facilitated cooperation and student engagement, but less on the school' emphasis on independent work.

However, across all classrooms, the absence or limited use of spatial zoning and a lack of spatial autonomy restricted the implementation of personalised learning and independent work as was aimed for in their vision. In this regard, the physical environment only partially supported the school's pedagogical and educational intentions, according to literature (see paragraph 3.2.2.) and classroom observations, see table 9 for an overview of the design and use characteristics within each observed classroom.

Table 9 - Observation of the design and use characteristics of each classroom at school A according to literature.

Category	Characteristics	Classroom 2.04	Classroom 2.07	Classroom 2.15	School A
	Subject	Dutch language	Dutch language	Physics	
Essential Design Elements	Layout & spatial logic	Classroom size: 8,8m x 7,5m. furniture enables moderate reconfiguration & flexibility. <2.5 m2/student.	Classroom size: 7,5m x 7,4m. Small room, reduced layout flexibility due to set-up. <2.5 m2/student	Classroom size: 10,1m x 7,5 m. Large room: furniture enables reconfiguration & flexibility. >2,5 m2/student.	
	(Ergonomic) furniture	Standard chairs and fixed-height tables; traditional single table rows of 2 for teacher-centred work.	Standard chairs and fixed-height tables; traditional single table rows of 2 for teacher-centred work. Tight rows limit adaptation.	Standard chairs and shared tables; tables for 2 in rows of 4 for collaboration between students. Group tables.	
	Workspace variety / Zoning	Single-purpose space and no flexible zones.	Single-purpose space and no room for flexible zones.	Room for group tables in the back which allow basic zoning when required.	
	Indoor Environmental Qualities (Light, acoustics, temperature and ventilation)	Sun-facing classroom. Temperature becomes uncomfortable after some time; High windows provide daylight and controlled acoustic conditions. No student-control, they cannot open the windows nor change the temperature.	High windows provide daylight and controlled acoustic conditions. No student-control, they cannot open the windows nor change the temperature	High windows provide daylight and controlled acoustic conditions. No student-control, they cannot open the windows nor change the temperature	
Supportive Design Elements	Personalisation of workspace	Uniform layout; no signs of student work and no opportunity for students to choose their preferred workspace or adapt it to their learning style.	Uniform layout, no signs of student work and no opportunity for students to choose their preferred workspace or adapt it to their learning style	Uniform layout; Student work (earlier projects and posters) displayed in the back of the classroom. Small opportunity for students to choose their preferred workspace or adapt it to their learning style (individual tables and group tables in the back).	
	Flexibility in room configuration	Fixed layout with space for adaptability / possibility for flexibility due to size.	Fixed layout; space constraints due to size.	Large space allows for more flexibility, but large tables and furniture limits the flexibility in the front.	
	Availability of learning materials	No visible tools or materials.	No visible tools or materials.	Visible storage, tools and resources for students.	
	Emotional and mental support	Bright and open feels formal and standard.	Bright and open feels formal and standard.	Open, less rigid layout and more welcoming but still feels formal.	
Architectural Design Aesthetics	Visual appearance	Neutral design, minimalistic; Green and white, bare walls, with no complementary tones or decoration. No visual engagement.	Neutral design, minimalistic; Green and white, bare walls, with no complementary tones or decoration. No visual engagement.	Neutral design but structured with displays related to the subject in balance with the cleanness of the room. More visual engaged classroom.	
	Openness	Large well-structured open space; flexible organised with space between the desks.	Smaller space limits openness. Desks are close to each other. Small space between the rows.	Large well-structured open space; flexible organised with space between the desks.	

	Natural elements & plants	No natural elements or plants	No natural elements or plants	No natural elements or plants
	Visual calm and clarity	Clean and visually clear structured.	Clean and visually clear structured.	Clean and visually clear structured.
Functional Design Elements	Accessibility	Entrance & layout are functional with wide (>1,2m) walkways.	Entrance & layout are functional, but walkaways are tight between desks (<1,2m)	Entrance & layout are functional with wide (>1,2m) walkaways.
	Freedom of movement	Easily to move around the classroom with enough space between the rows.	Fixed rows with less space between the tables. Restricts student movement.	Students can move easily in the classroom however table sizes restrict the space in between the rows.
	Practical use and layout	Traditional teacher-centred layout; Possible flexible layout due to size of the classroom.	Traditional teacher-centred layout; No space for adjustments due to the size of the room.	Traditional teacher-centred layout; Possible flexible layout due to size of the classroom.
	Sustainability	C2C-principles, lighting-sensor but no extra visible implementations	C2C-principles, lighting-sensor but not extra visible implementations.	C2C-principles, lighting-sensor but not extra visible implementations.

Based on the observations summarised in table 9 and the design principles according to literature as discussed in chapter three, the three classrooms at School A show varying degrees of alignment with the literature in relation to the four design and use categories:

Essential Design Elements

This category includes *Ergonomic furniture, spatial layout & logic, workspace variety & zoning,* and *IEQs*.

Classroom 2.07 displayed the lowest level of alignment with literature. Its small size and traditional layout with fixed furniture limited the possibility for flexible use. The room lacked differentiated zones and was clearly designed for frontal, teacher-centred instruction. Although the high-positioned windows with automatic sunscreens provided controlled daylight, students had no agency over the indoor climate, as is the same in 2.04 and 2.15, which limits satisfaction, motivation and productivity (Bluyssen et al., 2020). According to Barrett et al. (2015) and OECD (2017), such limited flexibility and lack of environmental control are known to negatively affect student motivation and productivity. This was observed within all the classrooms.

Figure 4.1 – Classroom 2.07

Classroom 2.04 was slightly more flexible in spatial layout, given its larger size (8,7m x 7,5m), but still featured standard fixed tables and chairs in traditional row arrangements. There was no zoning or designated space for independent or group work, which is considered a core element in effective classroom design (Kariippanon et al., 2017). The room is sun-facing, which leads to overheating becoming an issue (Bluyssen et al., 2020).

Figure 4.2 – Classroom 2.04

Classroom 2.15 demonstrated the strongest alignment with literature among the three. It offered the largest spacious layout (10,1m x 7,5m), group tables, ad designated back zone for work. These features enabled varied didactic formats and supported group-based learning activities, which is an essential condition for student-centred pedagogy as is supported by the pedagogical perspective within education (OECD, 2017; RVO, 2011).

Figure 4.3 – Classroom 2.15

Supportive Design Elements

This category includes *Personalisation of workspace, flexibility in room configuration, availability of learning materials,* and *emotional*

and mental support. Across the three classrooms, alignment with the literature on supportive elements was generally low.

Classroom 2.07 and 2.04 both lacked visible opportunities for personalisation: furniture layout was fixed and uniform, with no student choice in seating or display of student work. No learning materials or tools were visibly accessible, and both rooms, while bright and open, felt formal and standard. According to OECD (2017) and Woolner et al. (2015), this absence of ownership and visual stimuli can negatively affect students' motivation, satisfaction and even productivity.

Figure 4.4 – Classroom 2.15

Classroom 2.15 showed partial alignment with supportive design principles. While the layout was still uniform, some student work was displayed in the back, and tools and materials were visible and accessible. The space felt more open and less rigid, contributing to a slightly more welcoming atmosphere. However, it remained relatively formal, limiting its full potential to support student satisfaction and motivation (Blatchford et al., 2003; Barrett et al., 2015).

Architectural Design Aesthetics

This category includes *visual appearance, openness, natural elements,* and *visual clarity*. The observed classrooms showed limited aesthetic variation and overall minimal alignment with architectural design principles highlighted in the literature.

All three classrooms featured neutral, minimalist interiors – mostly green floors and white walls – with bare walls and little to no decorative elements (see figure 4.2). In classroom 2.07 and 2.04, this resulted in a lack of visual engagement, contradicting recommendations by Woolner (2017) and Barrett et al. (2015), who argue that thoughtfully designed, stimulating spaces can enhance focus and motivation.

Classroom 2.15 stood out slightly due to structured displays of student work that adds some visual appearance without overwhelming the space. This balance between calm and stimulation aligns more closely with what is suggested in the aesthetic guidelines for learning environments by Woolner (2017).

So, all classrooms were visually calm and clearly structured. No natural elements or plants were observed. Only classroom 2.15, in comparison to 2.04 and 2.07, offered elements of aesthetic engagement beyond basic functionality.

Functional Design Elements

This category includes *Accessibility, freedom of movement, practical use and layout,* and *sustainability.* Overall, the observed classrooms at school A showed only partial alignment with functional design principles as described in the literature.

Classrooms 2.04 and 2.15 offered sufficient accessibility, with entrances and layout included walkways wider than 1.2 metres, facilitating circulation and ease of entry. Classroom 2.07, however, measured narrow pathways (<1,2m) between tightly arranged desks, which limited both accessibility and movement – conditions shown to reduce student satisfaction, motivation and productivity (OECD, 2017).

In terms of freedom of movement, classroom 2.04 allowed students to navigate the space relative easily due to the size and openness, although its traditional setup limited reconfiguration. Classroom 2.07 most strongly restricted movement due to its small size and fixed layout. Classroom 2.15 used large furniture (2-persons desks) that limited flexibility and the possibility to move around easily. All three classrooms followed a traditional teacher-centred layout, with only minimal indications of adjustable or student-driven configurations. This conflicts with the call for adaptable learning environments that support varied teaching strategies (Barrett et al., 2015).

Regarding sustainability, all classrooms incorporated lighting sensors aligned with Cradle-to-Cradle (C2C) principles, a sustainable design framework that promotes the continuous reuse of materials in closed loops

to eliminate waste and support environmentally regenerative systems. However, no further sustainable features—such as visible materials, renewable systems, or user-awareness prompts—were observed. According to Van der Hoeven et al. (2022), sustainability should be integrated not only technically but also educationally and visibly within the learning environment.

The analysis of case A illustrates how educational and pedagogical ambitions can be partially supported – but also constrained – by the spatial characteristics of traditional secondary school classrooms. While some elements, such as layout flexibility and visual clarity, were present in varying degrees, other essential and supportive aspects – particularly zoning, personalisation, and student autonomy – remained underdeveloped. To explore how a different spatial context might influence teaching and learning dynamics, as will be explained in 4.2, a second case study is introduced.

School B, located in Rotterdam and offering secondary education at HAVO and VWO levels, presents a contrasting environment due to its recently renovated classrooms, designed with flexibility, collaboration, and innovation in mind, see table 10 for school profile.

Table 10 – School profile School B.

School	School B, Rotterdam
Building year	2006
Design principle	Creating focus on personal and education development, cultural awareness and innovation.
Educational tracks	HAVO & VWO + technasium, codasium and global citizenship (Wereldburgerschap)
Students	± 630 students (ages 12-19)
Surface area	± 4415 m^2 gross floor area
Location	Rotterdam
SES-Context	Relatively low-middle socio-economic status with divers student population
Keywords observation	Student-centred classroom opportunities (Collaborative set-up).

For this case study, two classrooms were selected for in-depth observation and analysis: *classroom 0.10* and *(a combined) classroom 2.01-2.02* (see table 11). The selection was based on their differences with the analysed traditional classrooms in case A.

Table 11 – Classroom profiles profile school B.

Classroom	Subject	Size	Capacity	M2 / student	Furniture & layout
0.10	Global Citizenship (WBS)	9.3 m x 7.8m	28-30 students	28 students: 2.6 m2/student 30 students: 2.5 m2/student	Collaborative layout with group tables and diverse furniture for students (high tables and high chairs versus lower)
2.01-2.02	Codasium	16.2m x 7.8m (Divided in 2 rooms: 7.0m x 7.8m 9.2m x 7.8m)	28-30 students	28 students: 4.5 m2/student 30 students: 4.2 m2/student	Traditional rows, standard desks and chairs (tighter layout) in room 1 Collaborative layout in room 2

School B's vision is shaped by two core perspectives:

- From an educational perspective, the school promotes 21st-century competencies such as critical thinking, collaborative problem-solving, and global awareness. Interdisciplinary learning, project-based activities, and real-world applicability are central to the curriculum.
- From a pedagogical perspective, emphasis is placed on student agency, active participation, and peer learning. Teaching is intended to be interactive and student-centred, with learning environments that support exploration, autonomy and meaningful engagement.

These ambitions are translated into practice through the use of collaborative layouts, flexible furniture, and thematic subjects such as Global Citizenship (WBS), which inherently invite student dialogue. Classroom 010 reflects this approach through a collaborative layout with diverse group tables and varied furniture heights for preference, supporting both formal and informal interaction, see figure 4.5.

Classroom 2.01-2.02, although larger and physically flexible, displays a spatial and functional split: Room 1 (7.0m x 7.8m) retains a more traditional, teacher-centred setup with tightly arranged desks, while room 2 (9.2m x 7.8m) offers a more open, collaborative layout, see figure 4.7.

This internal contrast provides valuable insight into how spatial design may support or hinder the consistent enactment of educational intentions within a single school, see table 12 for an overview of the design and use characteristics of each classroom.

The two observed classrooms revealed varying levels of alignment within these values, with Classroom 0.10 showing a stronger and more consistent translation of the school's collaborative and student-centred vision into spatial practice, while classroom 2.01–2.02 presented a mixed implementation due to its functional split.

Table 12 – Analysis of the classroom environments of school B according to literature.

Category	Characteristics	Classroom 0.10	Classroom 2.01 – 2.02	School B
	Subject	Global Citizenship (WBS)	Codasium	
Essential Design Elements	Layout & spatial logic	Classroom size: 9.3m x 7.8m. Flexible and reconfigurable layout supports group work. >2.5 m2/student	Classroom size: Room 1 (7m x 7,8m) & Room 2 (9.2m x 7.8m); Traditional (room 1) and practical/ collaborative education (room 2) combined in 2 zones. >2.5 m2/student	
	(Ergonomic) furniture	Variation in furniture+ Offering ergonomic furniture and student preferences.	Standard chairs and shared tables for two; Offering limited adjustability due to size of tables.	
	Workspace variety / Zoning	Zoned into collaborative clusters within the same room. Divided by furniture types.	Dedicated zones (Room 1 and 2) and divided by a glass wall in between.	
	Indoor Environmental Qualities (Light, acoustics, temperature and ventilation)	Good – High windows provide daylight access and controlled acoustic conditions. Students can open the windows and lower the sunscreen when necessary. They can't change the temperature.	High windows provide daylight access and controlled acoustic conditions. Students can open the windows and lower the sunscreen when necessary. They can't change the temperature.	
Supportive Design Elements	Personalisation of workspace (autonomy)	Option to work in different areas and seating positions. Student work on the wall and displayed in the back.	Option to choose seating and working area (2 group tables in 2.01). Student displays in the classroom, mainly 2.02.	
	Flexibility in room configuration	Rearrangeable for activities. Most furniture on wheels.	Most furniture is fixed (2.02) reduces flexibility. Large elements (e.g. tables in 2.01-2.02) which limits space.	
	Availability of learning materials	No visible tools or materials.	Required equipment present with visible resources / materials.	
	Emotional and mental support	Bright and open; Inviting atmosphere. Reported as emotionally supportive and cozy by students.	Mixed: Room 2.01 has a formal setting. Room 2.02 more open and lighter. However, the environment lacks soft textures and colours. No specific features that enhance comfort.	
Architectural Design Aesthetics	Visual appearance	Neutral and calm colour palette with complementary tones; Modern and inviting aesthetic. Subject-specific design. Visually engaging.	Neutral and calm colour palette with complementary tones. Classroom 2.01 formal and rigid design Classroom 2.02 appears brighter but messier.	
	Openness	Open visual access and freedom.	Partially open layout but with division between zones and fixed furniture in open space [2.02].	
	Natural elements & plants	No natural elements or plants.	No natural elements or plants.	
	Visual calm and clarity	Clean and visually clear structured. Minimal clutter supports visual focus.	Some clutter in the classrooms reduces visual focus, mainly 2.02.	
Functional Design Elements	Accessibility	Entrance & layout are functional with wide (>1,2m) walkways.	Entrance & layout are functional. Separate entrances to both rooms and interconnected. Limited space for walkways in 2.01 (<1,2m).	
	Freedom of movement	Students can move freely between tables.	Movement limited due to the size of the tables and fixed furniture in 2.02.	
	Practical use and layout	Supports varied learning activities but a few chairs are faced with their backs to the front of the class.	Supports varied learning activities well. Possibility to divide the group in 2 without losing sight through the glass panel.	
	Sustainability	No visible implementations.	No visible implementations.	

Based on the observations summarised in table 12 and the design principles according to literature as discussed in chapter three, the two classrooms at school B show varying degrees of alignment with the literature in relation to the four design and use categories.

Essential Design Elements

This category includes *Ergonomic furniture, spatial layout & logic, workspace variety & zoning,* and IEQs. The two observed classrooms showed varied levels of alignment with the literature on essential design elements, however, differences between the rooms were notable.
Classroom 0.10 demonstrated the strongest alignment with the principles of spatial flexibility and ergonomic support. The room was designed to support group work and collaborative learning. The layout is open and reconfigurable, with diverse group tables and (curved) seating options that supported both formal and informal collaboration (see figure 4.5 and 4.6). The space was clearly zoned into activity areas using the furniture itself – such as the round tables, high seating at the windows, and relaxed corners for discussions – which supports differentiated learning modes. This aligns highly with the recommendations from Kariippanon et al. (2017) and OECD (2017), who emphasise the importance of flexible zoning supporting student productivity, motivation and peer interaction. The variety in furniture and seating types also reflects an awareness to the student's needs and ergonomic support, allowing students to work in positions suited to their preference or task. The daylight conditions were favourable due to large and high windows, and students have access to openable windows and to lower the sunscreen to control the daylight. Overall, the classroom provided a spatial setting highly conducive to collaborative, student-centred learning.

Classroom 2.01-2.02 presents a mixed spatial logic due to its dual-function design. Room 2.01 featured a traditional, teacher-centred layout, with fixed rows of identical desks and limited walking space (see figure 4.7). The lack of spatial variation and large furniture, such as the 2-persons desks, limits the possibilities for alternative instructional formats in room 1. By contrast, room 2.02 (see figure 4.8) displayed a more open and collaborative setup with distinct areas for group work, practical tasks, and informal seating. A central glass wall separated the two rooms. While it still allows for visual continuity, it highlights the functional differences between the spaces. Both rooms have access to natural daylight through large and high windows that can be opened by student, and they can also lower the sunscreens. However, students can not adjust the temperature, limiting full alignment with IEQ recommendations made by Bluyssen et al (2020).

Figure 4.5 – Classroom 0.10

Figure 4.6 – Classroom 0.10

Figure 4.7 – Classroom 2.01 [2.01-2.02]

Figure 4.8 – Classroom 2.02 [2.01-2.02]

Supportive Design Elements

This category includes: *personalisation of workspace, flexibility in room configuration, availability of learning*

materials, and *emotional and mental support*. The classrooms demonstrated mixed levels of alignemnt with literature on supportive design elements.

Figure 4.9 – Classroom 2.01 [2.01-2.02]

Classroom 010 showed strong alignment across the 4 elements. Students had the option to choose their seating and working areas, with distinct zones supporting various group dynamics and seating preferences. Student work was visibly displayed on the walls and the back of the classroom, reinforcing a sense of ownership and identity, practices supported by OECD (2017) and Dahlan (2013) as key contributors to motivation, productivity and satisfaction. Most furniture was on wheels, offering reconfigurability for different learning activities, which reflects principles of adaptive learning environments (Kariippanon et al., 2021). Despite the absence of visible materials or tools during observation, students described the space as emotionally supportive, with an inviting atmosphere shaped by layout and a cosy, student-friendly design, as will be explained in paragraph 4.2.

In contrast, classroom 2.01-2.02 showed partial alignment. While classroom 2.02 allowed for more personalisation and flexibility, resulting in more productivity and motivation, visible in student displays and zoning. Classroom 2.01 has a more rigid structure, limiting reconfiguration and reinforcing a formal setting. The size of, and even fixed, furniture in both spaces restriced adaptability and movement, particularly in room 2.01. The required tools and materials were visible and accessible for the students, aligning with Barrett et al. (2015). Both classrooms showed soft textures and colour accents that enhance emotional comfort (Woolner, 2015).

Classroom 0.10 better reflected the principles of supportive design, while 2.01–2.02 offered only selective support, particularly in the more collaborative room.

Architectural Design Aesthetics

This category includes: *visual appearance, oppeness, natural elements,* and *visual calm and clarity*. The classrooms demonstrated mixed levels of alignemnt with literature on supportive design elements.

Classroom 0.10 showed strong alignment with aesthetic principles. The space used a neutral but warm colour palette with modern, subject-specific design elements, making it visually engaging and inviting (Barrett et al., 2015). The layout felt open and well-organised, supporting visual access and spatial clarity. While no natural elements were observed, the lack of clutter enhanced focus and calmness.

Classroom 2.01–2.02 showed mixed results. The overall colour scheme was neutral and consistent, but Room 2.01 appeared more rigid and formal, while Room 2.02 felt brighter but slightly cluttered, which affected visual clarity. Despite the open layout in Room 2.02, the division between zones and presence of fixed furniture limited full spatial openness. As with 0.10, no natural elements or biophilic features were present.

Classroom 0.10 aligned most consistently with architectural aesthetics that support student comfort and engagement, while 2.01–2.02 demonstrated only partial alignment.

Functional Desing Elements
This category includes *accessibility, freedom of movement, practical us and layout,* and *sustainability*. The classrooms demonstrated mixed levels of alignemnt with literature on supportive design elements.

Classroom 0.10 showed a strong degree of functional alignment. The room had wide walkways and an open arrangement that allowed students to move freely between tables. The layout supported varied learning activities, although a few seats were positioned with their backs to the front of the class, which could limit visibility and interaction. No visible sustainability features were present.

Classroom 2.01–2.02 showed partial alignment. Both rooms had separate but interconnected entrances, supporting flexible access and singular use of the rooms. However, Room 2.01 had narrow walkways, and Room 2.02's large tables and fixed setup restricted movement and flexibility. The spatial configuration allowed the group to be visually divided without full separation—a practical feature for supervision and flexible teaching. As with 0.10, no visible sustainable implementations were observed.

While Classroom 0.10 was more functionally supportive in terms of mobility and layout, 2.01–2.02 offered spatial versatility but was limited by its tighter configuration.

The analysis of case B demonstrates how educational ambitions centred on flexibility, collaboration, and student autonomy can be more fully realised when supported by intentional spatial design. Classroom 0.10 reflected this alignment most clearly, offering personalisation, flexible layouts, and visual clarity. In contrast, the dual-zone layout of classroom 2.01-2.02, while the two rooms differ in structure and use, this contrast does not necessarily signal misalignment. Rather, it reflects a deliberate spatial differentiation that can support varied teaching methods and learning needs. When used intentionally, such a setup offers teachers and students the ability to switch between more structured and more collaborative formats—demonstrating that flexibility can also be achieved through purposeful spatial contrast, rather than uniform openness alone.

4.2. Statistical analysis

Using the student survey statistical data was obtained. In the bivariate analyses, almost all variables were highly significantly ($p<.01$) related to at least one other variable. However, as shown in table 13, many of these relationships were relatively weak or moderate correlated. Strong correlations were primarily found between the design characteristics themselves. These findings suggest that all assessed design elements are indeed relevant and necessary, with certain classrooms scoring more favourably than others. Nevertheless, the magnitude of these differences remains modest with just a few highlights that will be explained in the following sections.

As noted in paragraph 4.1, all constructs demonstrated sufficient internal consistency to indicate that the items can be reliably used together as a single construct (see table 14). Among all elements, the mediators displayed the highest correlation and were highly significant.

4.2.1. The mediators
The mediators in this study represent the core dimensions of the student learning experience. These three variables were included in the analysis both as separate outcome measures and as a combined construct to capture the multidimensional nature of how students experience their classroom environment.
The bivariate correlation analysis (Table 13) revealed strong and statistically significant relationships among all three mediators. The correlation between *satisfaction* and *motivation* was $r=0.82$ ($p< 0.01$), between satisfaction and self-perceived productivity $r=0.81$ ($p< .01$), and between *motivation* and *self-perceived productivity* $r=0.80$ ($p< 0.01$), see figure 4.11. These coefficients indicate a substantial degree of shared variance, indicating that the three dimensions are closely interrelated in how students evaluate their learning environment.

The internal consistency of the combined mediator construct was high, as demonstrated by a Cronbach's alpha of α= 0.88 (table 14), exceeding the commonly accepted threshold of 0.70 for scale reliability. This finding confirms that the three mediators can be meaningfully aggregated into a single composite measure for certain analytical purpose. In the analyses, the combined construct was calculated as the mean score of the three mediators and included as an additional variable in table 13 to visualise how the elements scored compared to the whole construct instead of each individual mediator.

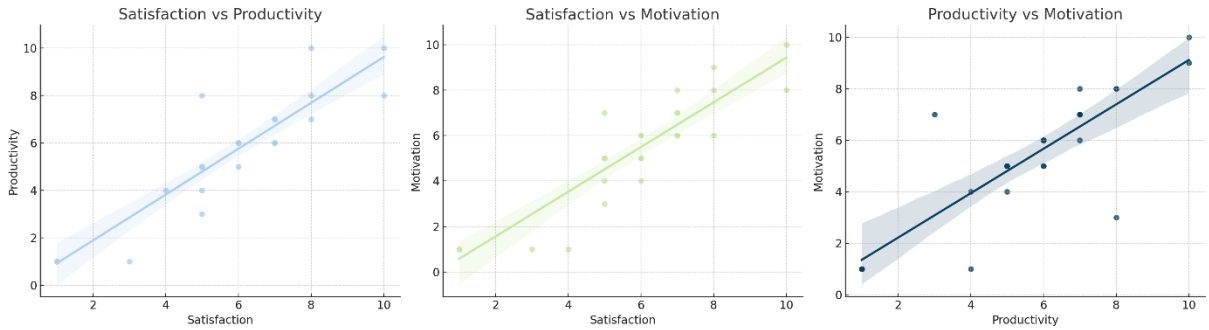


Figure 4.11 – Correlation between the 3 different aspects within case A [source: own figure]

However, relying exclusively on the composite score would risk overlooking meaningful differences in how specific classroom design features influence each dimension. For example, qualitative responses suggest that ergonomic furniture may strongly affect satisfaction, whereas a variety of workspaces may have a greater impact on motivation or productivity. Such patterns were also visible in classroom-level scores (Figure 4.12), where certain classrooms scored high on satisfaction but lower on productivity or motivation, and vice versa. For this reason, the findings at both the combined level – where the three mediators are treated as a single construct – and at the level of each individual mediator are being reported, to capture both overall and dimension-specific effects.

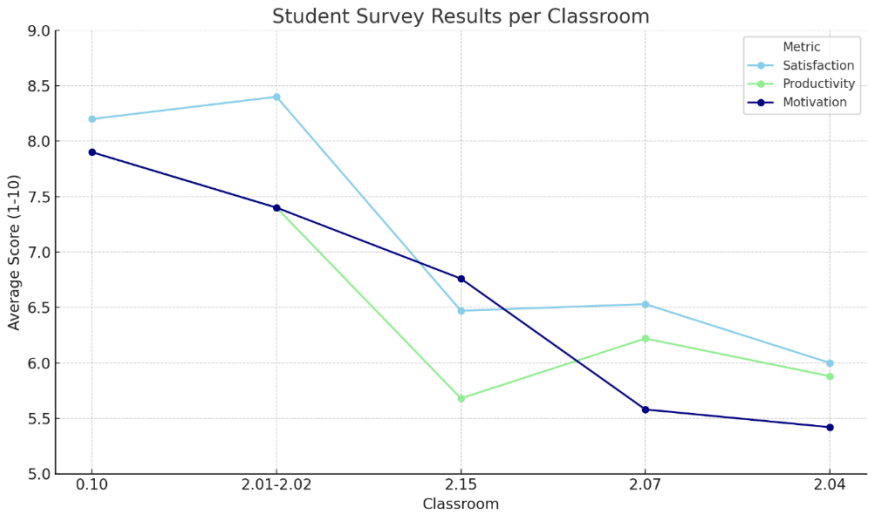


Figure 4.12 – Cross-case analysis: satisfaction, motivation and productivity scores for each case-unit [scale: 1-10] [Source: Own].

4.2.2. Personal characteristics

The personal characteristics considered in this analysis are the three educational levels from each school (nr.01-06) and the five participating classrooms (nr.07-11). These variables were examined in relation to the three mediators, design characteristics, and each other, in order to identify patterns that may help explain observed differences in the student learning experience.

Educational level

Regarding the educational levels of students, in school A 66% of students completed the survey; in school B this was 55% (see table 5). Students were distributed across educational levels and classrooms. As shown in table 13, some notable patterns emerge. In school A, classroom 2.04 is overrepresented by 4 HAVO students, which helps explain the weak negative correlations found for 4 VWO and 5 VWO students in those classrooms. A similar pattern is seen in classroom 2.15, where 4 HAVO students show a stronger negative correlation with the mediators. In school B, the educational levels are more evenly distributed across classrooms, with the highest number of respondents in *classroom 0.10*, followed by 2.01 and 2.02.

The correlation between educational levels and the mediators (satisfaction, motivation and productivity) are small but positive across levels. For school A, we observe a more static and general score per level, with mean scores between 5.66 and 6.89, and with standard deviations between 1.70 – 2.34 (table 15). These SD values are a bit higher compared to case B, indicating variability in perceptions among students within the same school. While the differences in means are modest, perceived productivity in school A scores slightly higher (r= 0.17*) than satisfaction and motivation.

Table 15 – Satisfaction, motivation and productivity scores for each level of school A [Mean and SD on scale: 1-10] [Source: Own].

School A, N=110		*Correlation*	*Mean*	*SD*
Satisfaction	4 HAVO	0.10*	6.28	2.18
	4 VWO	0.17*	6.89	1.80
	5 VWO	0.12	6.51	2.13
	Dummy School A	-0.43	6.56	2.09
(self-perceived) Productivity	4 HAVO	0.07	6.01	2.26
	4 VWO	0.15	6.44	1.70
	5 VWO	0.16*	6.55	2.13
	Dummy School A	-0.43	6.33	2.07
Motivation	4 HAVO	0.11	5.66	2.34
	4 VWO	0.17*	6.22	2.21
	5 VWO	0.10	5.98	2.32
	Dummy School A	-0.43	5.95	2.25

For school B, overall scores are higher compared to school A. The 4 HAVO and 4 VWO students reported higher satisfaction levels (4 Havo r=0.24*; 4 VWO r=0.26*), while 4 VWO and 5 VWO students scored higher on motivation (4 VWO r=0.20*; 5 VWO r=0.20*), see table 16. Here, the SD values range from 0.92 to 2.05, generally lower than in school A, suggesting a more consistent perception among students. In general, students in school B of classrooms 0.10 and 2.01-2.02, gave higher ratings across the mediators than students in school A, with a means varying from 6.87 till 8.63. This pattern is also reflected in the correlation coefficients when comparing classroom allocations with the three mediators.

Table 16 – Satisfaction, motivation, and productivity scores for each level of school B [Mean and SD on scale: 1-10] [Source: Own]

School B, N=63		*Correlation*	*Mean*	*SD*
Satisfaction	4 HAVO	0.24*	8.59	1.21
	4 VWO	0.26*	8.63	0.92
	5 VWO	0.19*	7.57	2.04
	Dummy School B	0.42	8.26	1.60
(self-perceived) Productivity	4 HAVO	0.08*	8.22	1.56
	4 VWO	0.12	7.38	1.85
	5 VWO	0.19*	7.39	1.53
	Dummy School B	0.41	7.66	1.62
Motivation	4 HAVO	0.14	8.00	1.70
	4 VWO	0.20*	8.63	1.60
	5 VWO	0.20*	6.87	2.05
	Dummy School B	0.43	7.83	1.91

Classrooms

The classrooms display a clear pattern with consistent outliers, as presented in Table 17. Classrooms in School A consistently show a weak to moderate negative correlation with the three mediators (r= –0.17** to –0.26**) with the combined construct of the student learning experience scoring a correlation coefficient of – 0.14(**) till -0.24(**). In contrast, classrooms in School B exhibit a moderate positive correlation, with coefficients ranging from r = 0.21(**) to 0.39(*).

Classroom 0.10 (school B) consistently achieves the highest scores across all three mediators—satisfaction (r = 0.37**), productivity (r = 0.39**), and motivation (r = 0.38**) —indicating a space that students systematically evaluate more favourably in terms of how they feel, work, and engage. These comments were also made by the students of classroom 0.10 within the open questions in the survey:

"A very pleasant and open classroom with comfortable seating options and great for collaboration." – Student A, 0.10 (see figure 4.13)

"It makes the lessons more enjoyable to watch and easier to pay attention." – Student B, 0.10

Figure 4.13 – Classroom 0.10 setting [Source: own].

Also, classroom 2.01-2.02 (school B) correlates positively with all mediators (satisfaction r=0.21**, productivity r=0.22**, and motivation r=0.27**). The hybrid setup of room 2.01-2.02 received mixed feedback from students. The classroom is divided into two physically connected but functionally divers areas. Room 2.01 follows a traditional classroom layout with fixed rows of deks (of 3 students each) and standard chairs, primarily used for instructional delivery. Students described this space as basic and spatially restrictive, particularly in comparison to 2.02.

Responses to classroom 2.01-2.02: "In the first part, you just sit in a normal classroom. The second room is better, because there you can work much more freely." – Student A, 2.01-2.02
"Spacious classroom, and you can make use of different zones." – Studen B, 2.01-2.02 (see figure 4.14).

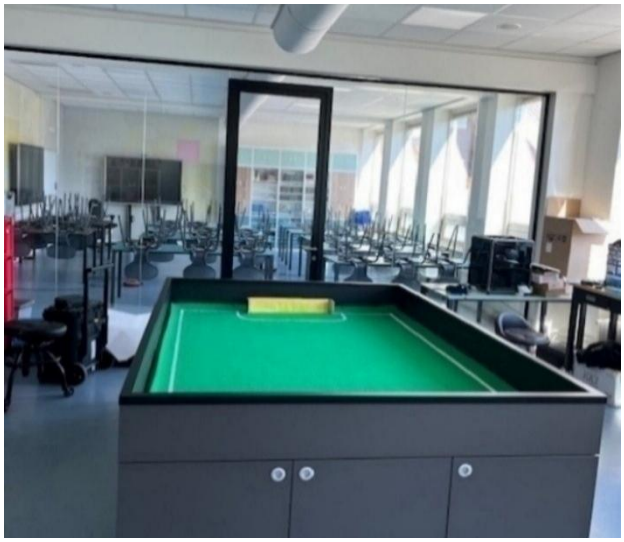


Figure 4.14 – Classroom 2.01-2.02 different work zones [Source: own].

Classroom 2.04 (school A), on the other hand, scored the lowest across all three mediators (satisfaction r= -0.26**, productivity r=-0.20**, and motivation r=-0.21**). Within the design elements, one notable outlier is the IEQ, which showed a strong negative correlation (r= -0.49**). Survey responses frequently mentioned that the room often felt too warm (6x), stuffy (6x), poorly ventilated (5x), or had an unpleasant smell (4x),all of which are factors known to negatively impact productivity, motivation and satisfaction, as explained in chapter 3. This classroom is locatd along the south façade, making it more susceptible to overheating, and the existing ventilation system does not sufficiently mitigate these conditions. Representative student comments illustrate these issues:

"It's sometimes quite warm and doesn't smell very fresh..." –Student A, 2.04
"It always smells bad, no fresh air. And it's a bit too small for our class." – Student B, 2.04

Table 17 – Effect sizes zoomed in for mediators in relation to classrooms [Source: Own]

		Case A: School A			***Case B: School B***			***Classrooms***				
	N=173	4 HAVO	4 VWO	5 VWO	4 HAVO	4 VWO	5 VWO	2.04	2.07	2.15	0.10	2.01-2.02
Constructs	Satisfaction	0.10*	0.17*	0.12	0.24*	0.26*	0.19*	-0.26**	-0.11*	-0.13*	0.37**	0.21**
	Productivity	0.07	0.15	0.16*	0.08*	0.12*	0.19	-0.20**	-0.11*	-0.22**	0.39**	0.22**
	Motivation	0.11	0.17*	0.15	0.14	0.20*	0.20*	-0.21**	-0.17*	-0.12*	0.38**	0.27**
	Student learning experience	0.07	0.18*	0.15	0.15	0.18*	0.20*	-0.24**	-0.14*	-0.17**	0.39**	0.18*

Table 13 - Effect sizes bivariate analyses

*Note **Significant at p<0.01 level (2-tailed), *Significant at p<0.05 level (2-tailed), darker shade = stronger correlation.*

			Personal Characteristics											Mediators				Design Categories															
			School A			School B			Classrooms					Constructs				Essential Design Elements				Supportive design elements				Architectural Design Aesthetics				Functional Design Element			
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Personal Characteristics	School A	1. 4 HAVO	1																													
		2. 4 VWO	-0.62**	1																												
		3. 5 VWO	-0.52**	-0.35**	1																											
	School B	4. 4 HAVO	0.47**	-0.19**	-0.35**	1																										
		5. 4 VWO	-0.06*	0.21**	-0.15*	-0.18**	1																									
		6. 5 VWO	0.53**	0.27**	-0.28**	-0.33**	-0.14*	1																								
	Classrooms	7. Classroom 2.04	0.56**	-0.30**	-0.34**	0.23**	0.08*	0.71**	1																							
		8. Classroom 2.07	-0.15*	0.18**	-0.08*	0.41**	0.22**	-0.20**	-0.29**	1																						
		9. Classroom 2.15	-0.48**	0.36**	0.19*	-0.23**	-0.11*	-0.19**	-0.27**	-0.25**	1																					
		10. Classroom 0.10	-0.04*	-0.25**	0.28**	0.35**	0.24*	0.27**	-0.34**	-0.32**	-0.30**	1																				
		11. Classroom 2.01	0.11*	0.07*	-0.19*	0.15*	0.07*	0.12*	-0.17**	-0.16**	-0.15*	-0.19*	1																			
Mediators	Constructs	12. Satisfaction	0.10*	0.17*	0.12	0.24*	0.26*	0.19*	-0.26**	-0.11*	-0.13*	0.37**	0.21**	1																		
		13. Productivity	0.07	0.15	0.13*	0.08*	0.12*	0.19	-0.20**	-0.11*	-0.22**	0.39**	0.22**	0.81**	1																	
		14. Motivation	0.11	0.17*	0.10	0.14	0.20*	0.20*	-0.21**	-0.17*	-0.12*	0.38**	0.27**	0.82**	0.80**	1																
		15. Student Learning Experience (construct)	0.07	0.18*	0.13	0.15	0.18*	0.20*	-0.24**	-0.14*	-0.17**	0.39**	0.20*	0.94**	0.94**	0.93**	1															
Design and use Categories	Essential Design Elements	16. Ergonomic Furniture (C101)	0.11*	0.18*	0.25**	0.30*	0.27*	0.23*	0.19*	0.20**	0.32**	0.57**	0.28**	0.62**	0.60**	0.61**	0.64**	1														
		17. Variety of workplace (C102)	0.08*	0.12*	0.17*	0.22*	0.13*	0.25*	0.13**	0.34**	0.23*	0.52**	0.25**	0.57**	0.56**	0.55**	0.61**	0.67**	1													
		18. Layout & Spatial logic (C103)	0.03*	0.12*	0.10*	0.29*	0.14*	0.13**	0.18*	0.23**	0.06*	0.37**	0.25**	0.63**	0.65**	0.63**	0.71**	0.68**	0.68**	1												
		19. IEQ (C104)	-0.30**	-0.06*	0.07*	0.11*	0.14*	0.15*	-0.49**	0.06*	0.05*	0.41**	0.11*	0.57**	0.50**	0.55**	0.57**	0.55**	0.53**	0.62**	1											
	Supportive Design Elements	20. Personalisation of workspace (C201)	-0.08	0.11	0.13	0.25**	0.11	-0.23*	0.22**	0.04*	0.16*	0.36**	0.20*	0.50**	0.51**	0.49**	0.53**	0.52**	0.45**	0.53**	0.45**	1										
		21. Flexibility in room configuration (C202)	-0.16	0.10	-0.03	0.05	0.03	-0.13	0.29**	0.09*	0.01*	0.40**	0.19*	0.51**	0.41**	0.50**	0.49**	0.51**	0.47**	0.59**	0.55**	0.52**	1									
		22. Availability of learning materials (C203)	-0.07	0.11	0.10	0.08	0.08	-0.10	0.24**	0.06*	0.01*	0.28**	0.28*	0.49**	0.43**	0.48**	0.50**	0.44**	0.35**	0.47**	0.55**	0.46**	0.58**	1								
		23. Emotional and mental support (C204)	-0.12	0.15	-0.08	0.20*	0.20*	-0.26*	0.30**	0.14*	0.05*	0.51**	0.28*	0.69**	0.68**	0.69**	0.74**	0.64**	0.58**	**0.77****	0.66**	0.57**	0.65**	0.53**	1							
	Architectural Design Aesthetics	24. Visual appearance (C301)	0.10	0.21	0.20*	0.13	0.19	-0.26*	0.20**	0.13*	0.20**	0.50**	0.25**	0.66**	0.63**	0.66**	0.70**	0.68**	0.62**	0.69**	0.66**	0.58**	0.54**	0.53**	0.72**	1						
		25. Openness (C302)	-0.17*	0.15	-0.19	0.16	-0.12	-0.08	0.31**	0.07*	0.10*	0.36**	0.02*	0.48**	0.49**	0.47**	0.53**	0.45**	0.48**	0.58**	0.50**	0.48**	0.46**	0.35**	0.54**	0.60**	1					
		26. Natural elements (C303)	0.04	0.13	-0.19	0.14	-0.03	-0.12	0.18**	0.12*	0.13*	0.28**	0.13*	0.45**	0.43**	0.44**	0.48**	0.40**	0.48**	0.51**	0.50**	0.52**	0.48**	0.51**	0.55**	0.60**	0.58**	1				
		27. Visual calm and clarity (C304)	-0.12	0.22*	0.20*	0.28*	-0.08	-0.23*	0.24**	0.15*	0.10*	0.42**	0.18*	0.57**	0.51**	0.57**	0.57**	0.53**	0.45**	0.59**	0.49**	0.46**	0.52**	0.46**	0.66**	0.59**	0.61**	0.49**	1			
	Functional Design Elements	28. Accessibility (C401)	-0.14	0.22*	-0.03	0.25*	0.09	-0.33**	0.29**	0.17*	0.03*	0.34**	0.17**	0.50**	0.46**	0.52**	0.52**	0.51**	0.41**	0.50**	0.47**	0.51**	0.50**	0.44**	0.58**	0.56**	0.45**	0.41**	0.51**	1		
		29. Freedom of movement (C402)	0.11	0.02	0.10	0.26*	0.10	-0.34**	0.18*	0.12*	0.18**	0.31**	0.17**	0.51**	0.55**	0.52**	0.58**	0.56**	0.50**	0.65**	0.48**	0.47**	0.54**	0.47**	0.66**	0.64**	0.45**	0.47**	0.60**	0.50**	1	
		30. Practical use of layout (C403)	-0.13	0.23**	0.20*	0.19*	-0.03	-0.17	0.20**	0.11*	0.09*	0.38**	0.25**	0.63**	0.65**	0.62**	0.68**	0.59**	0.55**	0.68**	0.62**	0.54**	0.55**	0.56**	0.68**	**0.76****	0.64**	0.62**	0.66**	0.64**	0.61**	1
		31. Sustainability (C404)	0.05	0.13	0.07	0.34**	-0.09	-0.29*	0.17*	0.07*	0.23**	0.35**	0.13*	0.50**	0.44**	0.50**	0.50**	0.61**	0.51**	0.63**	0.48**	0.42**	0.51**	0.32**	0.59**	**0.70****	0.55**	0.47**	0.58**	0.47**	0.57**	0.64**

Value of Pearson correlation coefficient	Strength	Value of significance (p)	Strength
> 0.80	Very strong	<0.01	**
0.5 – 0.8	Strong	0.01 – 0.05	*
0.2 – 0.5	Moderate	>0.05	-
0 – 0.2	Weak		
< 0	None		

4.2.2. Design and Use categories

These elements were examined in relation to the classroom of the students and its impact on their satisfaction, productivity, motivation, in order to identify patterns that may help explain observed differences in the student learning experience.

The statistical analysis shows that all elements are considered important and significant for the effective functioning of the design and use of classrooms, and they correlate strongly with satisfaction, productivity, and motivation. Nevertheless, several noteworthy outliers can be observed within each category, which will be discussed in the following sections.

Essential Design Elements

Within the category of essential design elements (nr. 16-19), the focus was placed on four aspects, as explained previously in chapter 3:

1) *Ergonomic furniture (C101)*
2) *Variety of workplace (C102)*
3) *Layout & spatial logic (C103)*
4) *IEQ (C104)*

When correlated with the three mediators (satisfaction, productivity, and motivation), all essential design elements showed a positive association, as presented in Table 18. However, there are some differences at the classroom level. *Classroom 0.10 (school B)* displayed strong positive correlations with *ergonomic furniture (C101)* and *variety of workplaces (C102)*, while *classroom 2.04* stood out for its strong negative correlation with *IEQ (C104)*.

Table 18 - Effect sizes zoomed in for relation to essential design elements [Source: Own]. *Note:* >0.8 = very strong positive/negative relationship; 0.5–0.8 = strong positive/negative relationship; 0.2–0.5 = moderate positive/negative relationship.

		Mediators			**Classrooms**				
		Satisfaction	productivity	Motivation	2.04	2.07	2.15	0.10	2.01-2.02
Essential Design Elements	Ergonomic Furniture (C101)	0.62**	0.60**	0.61**	0.19*	0.20**	0.32**	0.57**	0.28**
	Variety of workplace (C102)	0.57**	0.56**	0.55**	0.13**	0.34**	0.23*	0.52**	0.25**
	Layout & spatial logic (C103)	0.63**	0.65**	0.63**	0.18*	0.23**	0.06*	0.37**	0.25**
	IEQ (C104)	0.57**	0.50**	0.55**	-0.49**	0.06*	0.05*	0.41**	0.11*

Classroom 0.10 (school B) shows a strong positive correlation with *ergonomic furniture* (r= 0.57**) and *variety of workplaces* (r= 0.52**) that are both highly significant. This is also evident in the room's physical setup, where students benefit from a variety of adjustable furniture and more flexible spatial arrangements, in contrast to the more traditional layouts seen in other rooms (see table 9 and 12), which scored also lower (see figure 4.15 and 4.16). This was corroborated by students, who frequently made similar remarks in the open-ended responses of the survey: **"***The furniture here is much more comfortable, I can really find a good spot to work."* – Student C, 0.10

Students who were able to choose their work environment when flexible work areas matched their task types, reported higher correlations with motivation (r=0.38**), productivity (r=0.39**), and satisfaction (r=0.37**), see classroom 010 compared to the others. In general classroom 010 scored the highest in relation to the combined construct of the *student learning experience* (r=0.39**) followed by classroom 2.01-2.02 (school B) with its combined 2 classrooms. However, students reported that this setup was not always used effectively during lessons: *"We only use the space at the back every now and then, mostly after school or for special projects. During regular lessons, it just stays empty."* (Student C, 2.01–2.02). Teacher confirmed this, noting that in practice it was more challenging for them to maintain oversight with this dual-zone layout: *"From the front, it's harder to see what everyone is doing when they're spread out in different arrangements, so I tend to keep them in a more traditional setup."* (Teacher A, 2.01–2.02). This may

explain the moderate positive correlations for C102 and C103 in classroom 2.01-2.02. In classroom 2.15, the positive correlation for C102 could be attributed to the presence of group tables at the back of the room. For the rest, classrooms 2.07 and 2.15 (school A) also showed moderate positive correlations for C102 and c103, although current observations make it difficult to determine the exact cause. Classroom 2.04 (school A) scored the weakest correlation among the 5 rooms for C101-C103.

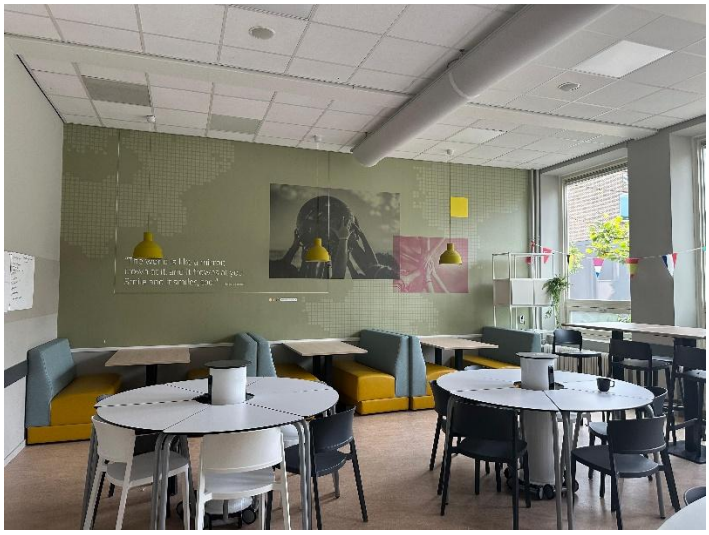


Figure 4.15 – workspace variety & furniture classroom 010.

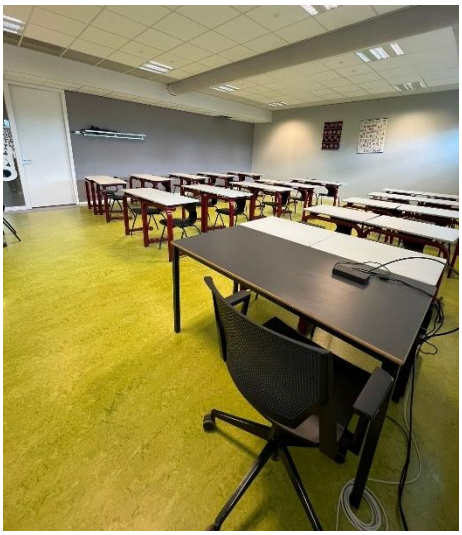


Figure 4.16 – Standard classroom layout 2.04

However, Classroom 2.04 presented a strong negative correlation with the *IEQ* (r = –0.49**), as discussed previously in section 4.3.2. This aligns with multiple open-ended survey responses, in which students repeatedly mentioned issues such as poor air quality, unpleasant odours, and high indoor temperatures. The room's location along the south façade makes it more prone to overheating, while the existing ventilation system fails to sufficiently address these conditions.

"It's sometimes quite warm and doesn't smell very fresh..." – Student A, 2.04
"It always smells bad, no fresh air. And it's a bit too small for our class." – Student B, 2.04

This aligns with the findings of Bluyssen (2020), who argues that when the IEQ is suboptimal for a learning environment, the classroom – regardless of other qualities – is likely to be evaluated less favourably, which we also see in the other correlations. However, the teacher consistently praised 2.04, valuing its clarity and spatial layout. According to the teacher's perspective, layout and space were the most influential sub-factors:
"I think about the size. That they actually have more space to move around... I would say there [2.04], because it's nicer to teach in a slightly more spacious classroom with a bus-style seating arrangement. You're more alert to the students there, and they pay attention more quickly." – Teacher.

This reflects the teacher's prioritisation towards spatial order and didactic control. However, students did not share the same appreciation for 2.04, criticizing physical discomfort due to poor ventilation, heat, and stuffiness. The teacher recognised these limitations but still preferred the doom due to its instructional affordance. This divergence highlights mismatch between students and teachers. While teachers' emphasis layout functionality more, students experience comfort and climate as central to cognitive engagement.

Supportive Design Elements

Within the category of supportive design elements (nr. 20-23), the focus was placed on four aspects, as explained previously in chapter 3:

1) *Personalisation of workspace (C201)*
2) *Flexibility in room configuration (C202)*
3) *Availability of learning materials (C203)*
4) *Emotional and mental support (C204)*

The bivariate correlations with the three mediators (satisfaction, productivity, and motivation) ranged from weak to strong positive values, as presented in Table 19. *Classroom 0.10* (school B) displayed a strong positive correlation with *emotional and mental support (C204)* (r= 0.51**, p<.01), alongside consistently moderate correlations for the other supportive design elements compared to other classrooms.

Table 19 - Effect sizes zoomed in for relation to supportive design elements [Source: Own]. *Note:* >0.8 = very strong positive/negative relationship; 0.5–0.8 = strong positive/negative relationship; 0.2–0.5 = moderate positive/negative relationship.

		Mediators			**Classrooms**				
		Satisfaction	productivity	motivation	2.04	2.07	2.15	0.10	2.01-2.02
Supportive Design Elements	Personalisation of workspace (C201)	0.50**	0.51**	0.49**	0.22**	0.04*	0.16*	0.36**	0.20*
	Flexibility in room configuration (C202)	0.51**	0.41**	0.50**	0.29**	0.09*	0.01*	0.40**	0.19*
	Availability of learning materials (C203)	0.49**	0.43**	0.48**	0.24**	0.06*	0.01*	0.28**	0.28*
	Emotional and mental support (C204)	0.69**	0.68**	0.69**	0.30**	0.14*	0.05*	0.51**	0.28*

In this study, the strong association observed in classroom 0.10 (school B) aligns with the perspective that emotional and mental support helps reduce overstimulation and foster psychological safety, allowing students to remain motivated, and maintain higher levels of productivity (OECD, 2017). Students in classroom 0.10 also reported higher correlation coefficients for satisfaction (r=0.37**, p<.01), productivity (r=0.39**, p<.01), and motivation (r=0.38**, p<.01).

Figure 4.17 – Classroom personalisation by student work and posters.

Overall, Classroom 0.10 outperformed the other classrooms on all four supportive design elements, offering opportunity for personalisation with student work and posters (see figure 4.17), offering storage for learning materials, and flexibility in room configuration (see figure 4.15). This is also confirmed by the students:

"It is nice that you can work and sit together with other students, because it feels more pleasant than sitting in a fixed pair. It feels as if you have more freedom in class while still being able to pay attention to the teacher." – Student D, 0.10
"An attractive classroom really helps with concentration and student cooperation." – Student E, 0.10
"Nice atmosphere with a homely feel. It's a chill classroom with comfortable chairs. I think it's a beautiful classroom and it makes you more social..." – Student F, 0.10. "

These comments illustrate how design elements such as flexible seating, personalisation opportunities, and a welcoming atmosphere can enhance feelings of comfort and social connection. However, not all student feedback was unreservedly positive. Some raised concerns about distraction: "I like the concept of the layout, but in practice it is less convenient because many students get distracted." – Student G, 0.10 Teachers also echoed this sentiment, highlighting the tension between openness and instructional control:

"Yes especially, when you still want to say something as a teacher. Then they are still kind of busy with each other" or "So you could say the classroom looks nice. But it's actually not suitable for didactics, for direct instruction." – Teacher A, 0.10

Classroom 2.01-2.02 (school B) scored a positive correlation with C201, C203 and C204, due to its dual size it offers more space for storage (C203; see figure 4.18). The second room is designed as a workplace for codasium in which students can work on their own projects and use it to store their stuff (C203; r=0.28**, p<.01) (see figure 4.08). This allows the students more autonomy and possibility to personalise their workspace (C201; r=0.20**, p<.01). This is also confirmed by the students:

"Sometimes we use the back part for group work or to keep our stuff..." – Student D, 2.01-2.02
"I like working independently in the space at the back. I find it really relaxing, and it motivates me to actually get things done. It's quieter than working in the other classroom with everyone together." – Student E, 2.01–2.02

Figure 4.18 – Classroom 2.02 is used as storage for learning materials and provides a separate workspace for students that work on their codasium projects.

Classrooms 2.04 (school A) also showed moderate positive correlations for C201 - C204, although current observations make it difficult to determine the exact cause. This is particularly noteworthy because it shares similar elements with classroom 2.07 (see table 9; school A), which, together with 2.15 (school A), displayed weak correlations.

Architectural Design Aesthetics

Within the category of supportive design elements, the focus was placed on four aspects, as explained previously:

1) *Visual appearance (C301)*
2) *Openness (C302)*
3) *Natural elements (C303)*
4) *Visual calm and clarity (C304)*

When correlated with the three mediators (satisfaction, productivity, and motivation), all architectural design aesthetics showed a weak to strong positive correlation, as presented in Table 20. *Classroom 0.10* (school B) stood out, showing strong positive correlations with *visual appearance (C301;* r=0.50**, p<.01) and *visual calm and clarity (C304; r=0.42**; p<.01).*

Table 20 - Effect sizes zoomed in for relation to architectural design Aesthetics [Source: Own]. *Note:* >0.8 = very strong positive/negative relation; 0.5-0.8 = strong positive/negative relation; 0.2-0.5 = weak positive/negative relation.

		Mediators			**Classrooms**				
		Satisfaction	productivity	motivation	2.04	2.07	2.15	0.10	2.01-2.02
Architectural Design Aesthetics	Visual appearance (C301)	0.66**	0.63**	0.66**	0.20**	0.13*	0.20*	0.50**	0.25*
	Openness (C302)	0.48**	0.49**	0.47**	0.31**	0.07*	0.10*	0.32**	0.02*
	Natural elements (C303)	0.45**	0.43**	0.44**	0.18**	0.12*	0.13*	0.28**	0.13*
	Visual calm and clarity (C304)	0.57**	0.51**	0.57**	0.24**	0.15*	0.10*	0.42**	0.18*

These scores are consistent with the general observations (see section 4.1, table 12), in which classroom 0.10 aligns most strongly with aesthetic principles compared to other classrooms. The space used a neutral yet warm colour palette with modern, subject-specific design elements, making it visually engaging and inviting. This aligns with the correlation coefficients of classroom 0.10 with the three mediators:

satisfaction (r=0.37**, p<.01), *productivity* (r=0.39**, p<.01), and *motivation* (r= 0.38**, p<.01). Also, classroom 2.01–2.02 (school B) scored a positive correlation with the visual appearance (r = 0.25**, p< .01), likely due to its similar colour palette and modern, subject-specific design elements (figure 4.7–4.9), making it visually engaging and inviting. However, its overall score was slightly lower than 0.10, likely due to its visually busy appearance, which students remarked upon. This is also further reflected in the weaker correlation with visual calm and clarity (C304; r=0.18**, p<.01).

"It feels a bit too cosy to really get down to serious work, and the busy appearance makes it harder to focus." – Student F, 2.01–2.02

Despite all three classrooms of school A having a similar plain look and scoring negatively on all three mediators (r = –0.11 to –0.26**, p < .01), classrooms 2.15 and 2.04 showed a similar correlation coefficient (r = 0.20**, p < .01) with visual appearance (C301). The reason why classroom 2.07 deviates from this pattern remains unclear, as observations confirm it has the same overall appearance as 2.04 and 2.15.

The *visual appearance* (C301) showed the highest correlation with the three individual mediators (r=0.63** – 0.66**, p<.01), followed by *visual calm and clarity* (C304), which correlated strongly with satisfaction (r=0.57**, p<.01), productivity (r=0.51**, p<.01) and motivation (r=0.57**, p<.01) (see table 20). Classroom 0.10 scored the highest on C304 (r=0.42**, p<.01), likely due to its visual identity and order, and reduced clutter (see table 12), creating a setting that is stimulating without being overwhelming (figure 4.15). Student feedback confirms these findings:

“An attractive classroom really helps with concentration and student cooperation.” – Student E, 0.10
“A nice atmosphere – a chill classroom. Comfortable and beautiful.” – Student H, 0.10

However, some students rated the classrooms differently, with a standard deviation of 1.8, and expressed some contradictions:
“I like the concept of the layout, but in practice it is less convenient because many students get distracted.” – Student I, 0.10. “This classroom is too cosy and pleasant to really get down to serious work.” – Student J, 0.10

The teachers, on the other hand, acknowledged the value of aesthetics, noting that a pleasant environment can sustain attention and engagement:
“I think this new generation does value aesthetics. So if the classroom also looks nice, they might pay better attention than in a dull white room.” – Teacher B, 0.10.

This supports the view that aesthetics are no longer seen as decorative but pedagogically relevant or sustaining attention and engagement (Barrett et al., 2015). They also pointed out design choices, such as warm wall colours and bright accents, as intentional elements to boost atmosphere, while warning against overstimulation from too many visual stimuli:
“The classrooms we see here are quite warm in terms of wall color. I think that was done intentionally. Certain elements are really bright yellow.” – Teacher C
“For example, when you're in a classroom with a lot of color... you can get overstimulated. That’s probably why you often see the somewhat duller designs in classrooms. It helps keep the focus on the lesson.” – Teacher D

This caution aligns with the idea that while moderate aesthetic stimulation promotes emotional comfort, too much can distract, especially for adolescents with fluctuating attention spans. Interestingly, while the teacher appreciates the aesthetic contrast in 0.10 (school B), they also questioned its symbolic clarity:
“In that classroom, I do miss the feeling of actually being in a classroom. It feels a bit more like you’re in some kind of cafeteria.” – Teacher C, 0.10.

Interestingly, Classroom 2.04 (school A) also showed a relatively strong correlation for visual calm and clarity (r = 0.24**, p < .01). It is visually simpler than 0.10, has a more neutral design, and bigger in size compared to the other classrooms in school A (r=0.31**, p<.01 and 66m^2). This may offer a calm learning

environment that limits distractions, aligning with research that moderate aesthetic stimulation supports concentration and learning.

These perspectives reveal a nuanced balance that ensures that the space not only supports student engagement and motivation but also aligns with teaching practices, avoiding overstimulation or loss of instructional focus. As one teacher summarised: *"You don't adapt your lesson to the classroom; you let the classroom adapt to your lesson"*.

Functional Design Elements

Within the category of supportive design elements, the focus was placed on four aspects, as explained previously:

1) *Accessibility (C401)*
2) *Freedom of movement (C402)*
3) *Practical use of layout (C403)*
4) *Sustainability (C404)*

When correlated with the three mediators (satisfaction, productivity, and motivation), all functional design elements showed a weak to strong positive correlation, as presented in Table 20. Overall, all four functional design elements demonstrated weak to moderate positive correlations with relatively small variations between classrooms. *Classroom 0.10* (School B) stood out as the only classroom that displayed a moderate positive correlation with each element of the category. It consistently scored higher than the average across all elements, but without any single dimension showing an exceptional deviation from the other classrooms. The *practical use of layout* (C403; r=0.38**, p<.01) scored the highest among the four elements and across the 5 classrooms.

Table 21 - Effect sizes zoomed in for relation to functional design elements [Source: Own]. *Note*: >0.8 = very strong positive/negative relationship; 0.5–0.8 = strong positive/negative relationship; 0.2–0.5 = moderate positive/negative relationship.

		Mediators			**Classrooms**				
		Satisfaction	productivity	motivation	2.04	2.07	2.15	0.10	2.01-2.02
Functional Design Elements	Accessibility (C401)	0.50**	0.46**	0.52**	0.29**	0.17*	0.03*	0.34**	0.17**
	Freedom of movement (C402)	0.51**	0.55**	0.52**	0.18*	0.12*	0.18**	0.31**	0.17**
	Practical use of layout (C403)	0.63**	0.65**	0.62**	0.29**	0.11*	0.09*	0.38**	0.25**
	Sustainability (C404)	0.50**	0.44**	0.50**	0.17*	0.07*	0.23**	0.35**	0.13*

Classroom 0.10 scored higher on the practical use of the layout compared to other classrooms, reflecting its flexible arrangement and logical zoning that facilitate smooth movement and task-specific organisation. Students reported that the classroom's structure allowed them to quickly adapt to different activities:

"It's easy to move things around and set up for different tasks, so you can get started right away." – Student, 0.10

Similarly, *Accessibility (C401)* and *Freedom of movement (C402)* also correlated positively with all three mediators, with classroom 0.10 again outperforming others. Students appreciated the ease of access to resources and their workspace, as well as the absence of physical obstructions, which supported independent and collaborative work. In contrast, classrooms with fixed, busy, and traditional layouts scored a lower correlation, see similar results for the other four classrooms. Classroom 2.04 (school A) also showed a moderate positive correlation with C401, likely explained by its relatively spacious arrangement compared to the other two classrooms. This allowed students to move through the room more freely and quickly locate their desks without encountering obstructive elements, which may also account for its higher score on *Practical use of layout* (C403; r = 0.29**, p < .01) compared to 2.07 (school A) that was smaller in size (55 m^2) and 2.15 that used bigger size worktables for students that couldn't be moved around easily.

Classroom 2.01-2.02 (school B) also scored moderately on C403, despite providing a dual-zone layout. While this set up supports flexibility and functionality in principle, student and teacher responses indicated that the back zone was used less frequently during regular lessons (see student response C, 2.01-2.02), which may have limited its overall contribution to functionality.

Sustainability (C404) showed slightly weaker, but still significantly strong positive correlations with the mediators (r= 0.44**-0.50**, p<.01). Classroom 2.15 and 0.10 scored significant moderate correlations with this element. However, students were less vocal about sustainability compared to the other design elements, and classroom observations did not clearly reveal why these two classrooms outperformed the other three in this regard.

4.2.3. Case comparison

When the individual classroom profiles are compared side by side, a more layered understanding emerges of how different spatial configurations and design elements interact with student experience. While no single space can be labelled as 'the best' the variation in scores reveals where certain environments appear to align more closely with student preferences and needs.

Classroom 010 (school B) stands out for its consistently high positive correlations on several elements, especially the *ergonomic furniture* (C101), *variety of workspace* (C102), *emotional and mental support* (C204), and *visual appearance* (C301) shows a strong positive correlation, indicating that a combination of physical comfort, flexibility in workspace options, and supportive atmospheres may contribute to a more favourably student experience, which also reflected as the highest positive correlation between the student learning experience and classroom 0.10 (r=0.39**, p<.01).

While in general al design and use elements show a highly moderate to strong correlation with each mediator and combined construct (see table 13), a number of elements stand out in particular (see table 22). Several of these elements also appear prominently in relation to the broader combined construct of the three mediators, namely the *student learning experience*. Here, *layout & spatial logic* (C103; r=0.71**, p<.01), *emotional and mental support* (C204; r=0.74**, p<.01), and *visual appearance* (C301; r=0.70**, p<.01) show the highest correlations. This raises the question whether these elements play a particularly central role in how students experience and evaluate their learning environment as a whole, not just in specific classrooms. While the data and observations cannot establish precise causations for each specific classrooms, the overlap between the most prominent single elements and those tied to the overall learning experience is notable.

Table 22 – Ranking highest correlations between design and use elements and the student learning experience as combined construct of the 3 mediators. Note: >0.8 = very strong positive/negative relationship; 0.5–0.8 = strong positive/negative relationship; 0.2–0.5 = moderate positive/negative relationship.

	Category	*Design and use element*	*Correlation to 'student learning experience'*
#1	Supportive Design Elements	(C204) Emotional and mental support	0.74**
#2	Essential Design Elements	(C103) Layout & spatial logic	0.71**
#3	Architectural Design Aesthetics	(C301) Visual appearance	0.70**
#4	Essential Design Elements	(C101) Ergonomic furniture	0.64**
#5	Essential Design Elements	(C102) variety of workspace	0.61**

A notable finding is the strong negative correlation between *Indoor Environmental Quality (IEQ)* and classroom 2.04. This represents not only the lowest score within this classroom but also the lowest across all classrooms examined. The IEQ (C104; r= -0.49**, p<.01) was characterised by students and in the observations as a stuffy and less fresh indoor climate. Despite that this classroom presented weak to moderate positive correlations for the other design elements, this classroom consistently ranked lowest across all three mediators: satisfaction (r= -0.26**, p<.01), productivity (r= -0.20**, p<.01), and motivation (r= -0.21**, p<.01), and the construct *the student learning experience* (r= -0.24**, p<.01). This contrast highlight show strengths such as free movement, spatial logic and clarity can be undermined by inadequate environmental comfort factors.

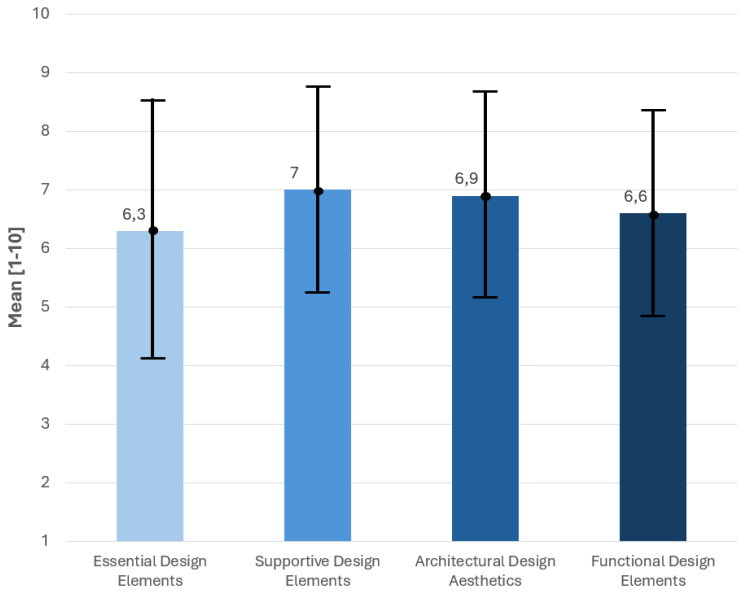
Although three classrooms in case A displayed similar design and use characteristics in observations, their correlations revealed differences. Based on the current observations and data, it is difficult to determine the exact cause of these discrepancies. One possible explanation lies in the differing composition of the dominant student groups per classroom: in 2.04, the 4 HAVO students were dominant, whereas 2.07 and

2.15 primarily consisted of 4 VWO and 5 VWO students (see table 5). Such variations in group composition can influence experience and perception, and these in turn can be shaped by multiple factors. However, further exploration of these potential influences lies beyond the scope of this study.

Across the four broader categories: *Supportive Design Elements (M= 7.0, SD= 1.8), Architectural Design Aesthetics (M=6.9, SD=1.8), Functional Design Elements (M=6.6, SD=1.9),* and *Essential Design Elements (M=6.3, SD=2.2)*, see figure 4.19, the mean scores suggest that no single category consistently dominates in perceived importance. Although *Supportive Design Elements* show the highest mean, the differences between categories are relatively small and the standard deviations (between 1.8-2.2) indicates limited variability in responses. This points to a relatively balanced valuation across categories, with students recognising the contribution of each dimension to their learning experience.

Visual patterns in the category-specific figures (table 20-21) add nuance to these findings. For instance, within *essential design elements*, blue shading appears more frequently across classrooms, signalling stronger and more consistent positive correlations for individual items. By contrast, functional design elements show more white space, suggesting that their relationship with student learning experience is weaker or more context dependent. This does not imply that one category is inherently more important than another, but rather that some dimensions—such as ergonomic comfort or spatial logic—are valued more consistently across settings, while others, such as functional adaptability, may depend more on the specific spatial configuration or teaching approach. The findings imply that rather than one category holding primacy, the interplay of comfort, aesthetics, functional layout, and essential features collectively shapes perceptions.

Table 23 – Perceived student means (± SD) for Essential, Supportive, Architectural, and Functional Design Elements [1 = very low, 10 = very high] (Source: own figure).



Category	Mean [1-10]	Standard deviation (SD)
Essential Design Elements	6.3	2.2
Supportive Design Elements	7.0	1.8
Architectural Design Aesthetics	6.9	1.8
Functional Design Elements	6.6	1.9

Chapter 05. Discussion

The aim of this study was to investigate *how the design and use of classroom environments influence the learning experience of secondary school students, focusing on student satisfaction, motivation and self-perceived productivity. In this chapter, the results are interpreted in light of existing literature, their underlying mechanisms are explored, and broader implications for theory and practice are discussed.*

5.1. The view on the student learning experience

As explained in earlier chapters, the student satisfaction, student motivation, and student self-perceived productivity were used to explore the students learning experience. The results of the statistical analysis show that the three mediators proved to be highly interrelated and internally consistent (Cronbach's α = 0.90; inter-item correlation = 0.81). These results indicate that students do not experience satisfaction, motivation and productivity as separate, isolated outcomes, but rather as interconnected dimensions of a single underlying construct: *the student learning experience*. While previous studies have sometimes argued that satisfaction, motivation, and productivity should be examined independently, arguing that each reflects a distinct psychological process (e.g., Barrett et al., 2015; Kariippanon et al., 2017), the present study found them to be strongly interrelated. This suggests that, at least in the context of classroom experience, these dimensions are better understood as interdependent elements of one overarching construct. The distinction proposed in earlier literature may therefore be more theoretical than empirical. Nevertheless, it remains possible that contextual or cultural factors shape these associations differently across learning settings, which can be explored further in future research.

In previous studies, these mediators were typically measured through self-report questionnaires. Student satisfaction was typically assessed via ratings of comfort and enjoyment of the classroom environment (Barrett et al., 2015; Bluyssen et al., 2020). The student motivation was measured through engagement- and interest-related items (Kariippanon et al., 2017), and the student self-perceived productivity was captured by items on perceived efficiency, focus, and performance in the classroom (Kuok Ho, 2023). Building on these approaches, this study included similar items to capture student learning experience as a composite of these three interrelated aspects by using self-report questionnaires for the students.

The results showing strong internal consistency not only validate the robustness of the measures but also raise questions about whether traditional distinctions between satisfaction, motivation, and productivity remain useful for contemporary classroom research. In practical terms, this interrelation implies that classroom environments that support students in feeling satisfied make them also more likely to report being motivated and productive as well. Although previous studies have not always approached these constructs in an integrated manner, the present findings strengthen the reliability of the research model and align with recent calls for a more holistic and student-centred perspective on classroom quality and on how student evaluate their learning environments (Appel-Meulenbroek et al., 2019; Kuok Ho, 2023). Viewing these mediators as a single, multidimensional construct helps clarifying how environmental characteristics of the classroom environment influence several aspects of the student experience simultaneously. This also suggests that interventions targeting only one dimension, may overlook broader systematic effects within the learning experience.

Furthermore, the results indicate that small improvements in the classroom, such as ergonomic furniture or more workspace variety, and spatial flexibility, can have multiplier effects that positively influence the students' experience. Previous studies similarly found that higher levels with these 3 mediators were associated with improved student engagement by 31% (Kariippanon et al., 2017), concentration and cognitive performance by 25% (Bluyssen et al., 2020), and effectively benefitted their learning process and productivity by 12% (Barrett et al., 2015). These earlier findings confirms our notion that the classroom environment influences not only isolated aspects of learning but also the overall experience of students as active participants in these educational settings. Building on this integrated understanding of the student learning experience, it becomes important to consider how specific aspects of the classroom design and use contribute to shaping these experiences.

These design and use elements in this study were grouped into four categories based on the framework of Dahlan (2008). The 16 design and use elements were selected based on (a) consistent relevance across

multiple studies, and (b) these elements could be meaningfully evaluated from a student perspective. Each element was then assigned to one of the four categories based on its primary function: essential elements represent physical and environmental preconditions (e.g., light, ergonomics); supportive elements facilitate daily classroom use and care (e.g., flexibility, learning materials); architectural aesthetics relate to the sensory and visual character of the space (e.g., colours, appearance, materials); and functional elements address accessibility and practicality in how the classroom can be used. This categorisation made it possible to combine both objectively observable and more subjective experience-based aspects into a coherent and measurable framework for survey-based assessment.

Whereas Dahlan (2008) primarily examined the statistical connection between classroom design and student's GPA's, this study shifts the focus from academic achievement to perceived student learning experience, capturing satisfaction, motivation, and self-perceived productivity as mediators. Interestingly, while Dahlan (2008) identified *supportive design elements* as the strongest statistical connection with student's GPA's, this study revealed that especially the *essential design elements* (e.g., ergonomic furniture, spatial logic, indoor environmental quality, and workspace variety) show a consistently strong relationship with the student's perceived experiences.

This finding suggest that the physical and ergonomic foundations of classroom environments may exert a more immediate influence on student's day-to-day learning experience, whereas supportive design elements, which shape autonomy and interaction, may contribute more indirectly or over a longer time frame. The contrast between the two studies likely reflects differences in both focus and also in context: Dahlan investigated academic performance among university students in Saudi Arabia, while the present research examined the learning experiences among secondary school students in the Netherlands. These contextual and demographic distinctions may explain why physical classroom conditions were found to have a more direct and noticeable effect on students' immediate perceptions, whereas social and functional aspects may play a cumulative role in shaping long-term engagement and academic performance.

These results correspond with recent findings by Bluyssen et al. (2020) and Kuok Ho (2023), who also highlight that improvements in ergonomic and spatial design can enhance students' motivation and satisfaction. Similarly, Barrett et al. (2015) found that even small improvements in classroom layout and environmental quality can cumulatively affect learning outcomes. This convergence across studies reinforces the importance of examining classroom design holistically rather than isolating single variables.

The results of the dataset show that all design and use elements were found to be highly significant ($p<.01$) predictors of the student learning experience, indicating that no single aspect of classroom design can be excluded or neglected for consideration. This comprehensive pattern is broadly consistent with the perspective emphasised by Barrett et al. (2015) and Bluyssen et al. (2020), who found that classroom performance results form the cumulative impact of several environmental factors rather than isolated features. However, unlike Dahlan's (2008) findings, which highlighted *supportive* elements as the strongest predictors of GPA, the current results indicate a more balanced distribution of influence when considering perceived experience instead of academic performance.

At the same time, some elements demonstrated stronger correlations than others, and particular classrooms revealed distinctive patterns that help to interpret the findings in a broader context. None of the classrooms in this study can be regarded as the 'ideal' classroom; however, the observed variations provide valuable insights into how specific design combinations can enhance or hinder the student learning experience. The purpose of this analysis was therefore not to identify the single best classroom, but to understand *why* certain configurations supported students' satisfaction, motivation, and perceived productivity more effectively than others.

Across all classrooms, results indicated that physical comfort and environmental quality formed the baseline for a positive experience, consistent with findings from Bluyssen et al. (2020) and Barrett et al. (2015). Classrooms that lacked sufficient indoor environmental quality (IEQ) or ergonomic conditions—such as classroom 2.04 (school A)—showed lower student satisfaction, motivation and perceived productivity, and the weakest correlation with the overall construct *student learning experience ($r= -0.24^{**}$; $p<.01$)*, despite other positive features. This classroom showed the highest negative correlation with the

IEQ (C104; r = -0.49**, p<.01). This supports previous research suggesting that inadequate physical conditions can overshadow the benefits of other design elements, underlining IEQ and ergonomics as *non-negotiable prerequisites* for effective learning environments.

Classrooms 2.07 and 2.15 (school A) also revealed weak negative correlations with the overall student learning experience (r = -0.14**, p < .01; r = -0.17**, p < .01), suggesting that even when basic conditions are adequate, a lack of flexibility and opportunities for personalisation can limit students' motivation and perceived productivity. These classrooms represented more traditional layouts with uniform seating and limited adaptability, which aligns with findings by Kariippanon et al. (2017), who argued that conventional classroom setups can constrain engagement when they fail to support individual learning preferences. Nevertheless, it is noteworthy that, despite these lower relative scores, the overall ratings in school A's classrooms remained above six on average, indicating that students still experienced their learning environments positively. This suggests that functional adequacy creates a sufficient baseline for comfort, but does not automatically lead to high satisfaction, motivation, or productivity.

However, once these fundamental conditions were met, differences in spatial flexibility and opportunities for personalisation became more influential. Classrooms that offered adaptable layouts or varied workspaces, such as 0.10 and 2.01–2.02 in school B, achieved higher levels of student motivation and self-perceived productivity. This aligns with the work of Kuok Ho (2023) and Kariippanon et al. (2017), who demonstrated that flexible and user-responsive classroom designs enhance students' sense of autonomy and engagement. Importantly, these classrooms did not necessarily represent highly innovative designs but rather integrated small, targeted improvements—such as visual appeal, workspace variety, and practical layout—that amplified students' overall experience. This finding reinforces the idea that incremental design interventions can still have meaningful impacts when they complement basic comfort and ergonomic needs.

Classroom 0.10 (school B) showed the strongest positive correlation with the student learning experience (r=0.39**, p<.01). Its high overall mean score (M = 8.0, SD= 1.7; see table 24) reflects a combination of flexibility, variety, and strong visual and emotional support, illustrating how design synergy—the interaction between comfort, adaptability, and aesthetics—enhances the perceived learning experience. These findings echo Barrett et al. (2015), who identified similar multiplier effects when multiple design dimensions aligned coherently, and reinforce the notion advanced by Thomas (2012) that classrooms designed with the end-user in mind—students—foster stronger emotional and cognitive engagement. The classroom also achieved the highest correlation, among the five rooms, for emotional and mental support (C204; r=0.51**, p<.01) and visual appearance (C301; r=0.50**, p<.01), further demonstrating that emotional and aesthetic qualities, such as pleasing visuals and a supportive atmosphere, are not superficial additions but integral components shaping students' willingness to engage and perform (Thomas, 2012).

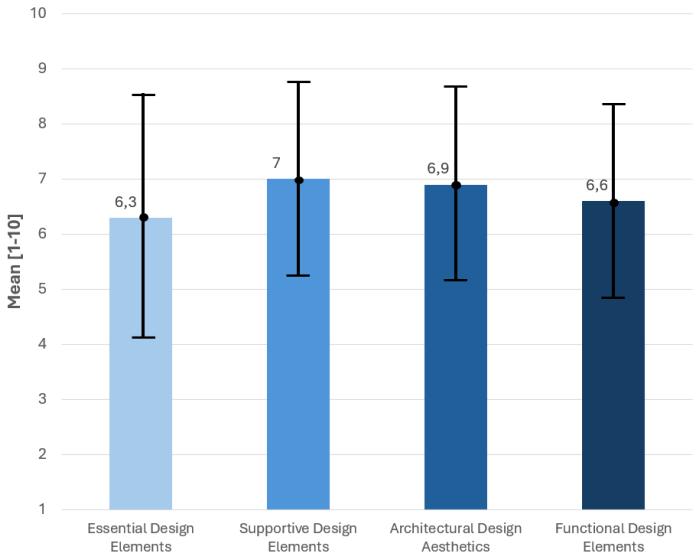
It is important to acknowledge the contextual specificity of these findings. The classrooms examined here belong to a limited sample of secondary schools in the Netherlands, and thus represent a particular pedagogical and cultural setting. Nevertheless, the results suggest broader implications: classrooms that balance physical quality with adaptability and emotional comfort may offer the most supportive environments for learning. Instead of defining a single 'ideal classroom', this study emphasises the importance of context-sensitive design strategies that combine functionality, flexibility, and psychological support to foster more positive student learning experiences. It's therefore important to recognise recognising that the most effective balance of design elements may vary between schools and user groups. Therefore, classroom 0.10 should not be seen as *the ideal* classroom. Rather, it can serve as an inspiring example that combines several positive aspects—such as variety of workspaces, visual appearance, and flexibility—which appeared to have a more positive impact on the student learning experience compared to the other four classrooms.

Table 24 – Mean and SDs of each observed classroom rated by students (N=173) [Source: own].

	Label (N=173)	Items (#)	Mean (1-10)	Standard deviation	**Correlation Student learning experience**
Classroom 2.04		**3**	**5.8**	**2.6**	**-0.24 ****
	Satisfaction	1	6.0	2.6	-0.26**
	Productivity	1	5.9	2.6	-0.20**
	Motivation	1	5.4	2.6	-0.21**
Classroom 2.07		**3**	**6.0**	**1.7**	**- 0.14****
	Satisfaction	1	6.5	1.5	-0.11**
	Productivity	1	6.2	1.4	-0.11**
	Motivation	1	5.6	1.9	-0.17**
Classroom 2.15		**3**	**6.0**	**2.0**	**-0.17****
	Satisfaction	1	6.5	1.9	-0.13**
	Productivity	1	5.7	1.9	-0.22**
	Motivation	1	5.8	2.1	-0.12**
Classroom 0.10		**3**	**8.0**	**1.7**	**0.39****
	Satisfaction	1	8.2	1.7	0.37**
	Productivity	1	7.9	1.6	0.39**
	Motivation	1	7.9	1.9	0.38**
Classroom 2.01-2.02		**3**	**7.8**	**1.6**	**0.20****
	Satisfaction	1	8.4	1.2	0.21**
	Productivity	1	7.4	1.6	0.22**
	Motivation	1	7.6	1.9	0.27**

Furthermore, the consistently high significance ($p < .01$) across all four design and use categories indicates that students perceive classroom quality as a multifaceted construct in which no single aspect dominates. This finding aligns with the holistic perspective advanced by Dahlan (2008) and Barrett et al. (2015), reinforcing the view that classroom environments should be conceived as integrated systems rather than collections of isolated features. The narrow variation in mean scores between the categories (M = 6.3–7.0, SD = 1.8–2.2; see Table 25) suggests that essential, supportive, architectural, and functional elements each contribute meaningfully and operate in a complementary manner, addressing different aspects of the learning experience. This balance implies that the effectiveness of classroom design does not depend on a single dominant factor but rather on the coherence between multiple design dimensions.

Table 25 – Perceived student means (± SD) for Essential, Supportive, Architectural, and Functional Design Elements [1 = very low, 10 = very high] (Source: own figure)



Category	Mean [1-10]	Standard deviation (SD)
Essential Design Elements	6.3	2.2
Supportive Design Elements	7.0	1.8
Architectural Design Aesthetics	6.9	1.8
Functional Design Elements	6.6	1.9

The analysis of the 16 individual design and use elements revealed that, although all elements have significantly impact on the student learning experience, the strength of their contribution varied. Two elements –*Ergonomic furniture* (C101; r=0.64**, p<.01) and *variety of workspace* (C102; r=0.61, p<.01**), see table 26 – stood out not only within this dataset but also because their relevance has already been empirically substantiated. These results align with previous research (Barrett et al., 2015; Kariippanon et al., 2017) showing that ergonomic comfort and spatial variety enhance focus, satisfaction, and

productivity.). As explained in paragraph 3.2.2., studies show that ergonomic furniture can help enhance physical comfort and productivity, leading to better academic productivity by 12% (Barrett et al. 2015), and allowing student to choose their work environment improves motivation and engagement by 31% (Kariippanon et al., 2017). These findings reinforce the notion that physical and spatial aspects of the classroom act as threshold conditions — once unmet, they constrain other potential benefits of classroom design (Bluyssen et al., 2020).

Table 26 – Correlation design and use elements: C101 & C102 with the mediators [Source: own figure].

	C101 *Ergonomic furniture*	*C102* *Variety of workspace*
Satisfaction	0.62**	0.57**
Productivity	0.60**	0.56**
Motivation	0.61**	0.55**
Student learning experience	**0.64****	**0.61****

Also the results highlight the importance of factors that have often been treated as *conceptual assumptions* in earlier literature, such as l*ayout and spatial logic* (C103), *emotional and mental support* (C204), *visual appearance* (C301), and *practical use of layout* (C403). All demonstrated significant positive relationships with the mediators (see Table 27). Previous studies by Gislason (2010), Kariippanon et al. (2017), and Sassoon et al. (2021) suggested that clarity, aesthetics, and a sense of support contribute to improved well-being and engagement, yet empirical validation of these assumptions remained limited. The study provides quantitative confirmation that these dimensions are not only theoretically relevant but also statistically significant contributors to students' satisfaction, motivation, and perceived productivity.

Table 27 – Correlation design and use elements: C103, C204, C301 & C403 with the mediators [Source: own figure].

	C103 *Layout & spatial logic*	*C204* *Emotional and mental support*	*C301* *Visual appearance*	*C403* *Practical use of layout*
Satisfaction	0.63**	0.69**	0.66**	0.63**
Productivity	0.65**	0.68**	0.63**	0.65**
Motivation	0.63**	0.69**	0.66**	0.62**
Student learning experience	**0.71****	**0.74****	**0.70****	**0.66****

These findings have important implications for understanding how classroom design operates beyond functional adequacy. They suggest that affective and sensory dimensions—such as emotional support and visual aesthetics—should not be considered as optional enhancements, but as integral components of the overall student learning experience. By providing empirical evidence for the relevance of these elements, this study bridges the gap between theoretical assumptions and measurable outcomes, underscoring the need for more holistic and human-centred classroom design approaches.

At the same time, the results reveal a layered relationship between the different design and use categories. Physical and ergonomic elements such as *furniture design*, *workspace variety*, and *indoor environmental quality* act as baseline essentials, forming the foundation for comfort and concentration. Once these are secured, enhancing aspects—including *visual appearance*, *layout clarity*, and *emotional support*—become increasingly influential, appearing to amplify students' satisfaction, motivation, and productivity when built upon essentials. This suggests that improvements in affective and aesthetic conditions may generate multiplier effects, enhancing the overall student learning experience. This interpretation is grounded in the observed interaction patterns within the dataset. Classrooms with low baseline scores—particularly those with insufficient indoor environmental quality or ergonomics—showed weak or even negative correlations between enhancing factors and the overall student learning experience. In contrast, when baseline conditions were strong, as in classrooms 0.10 and 2.01–2.02, the enhancing aspects such as layout clarity, visual appearance, and emotional support showed markedly stronger associations with satisfaction, motivation, and perceived productivity.

This study therefore introduces a conceptual distinction between baseline essentials and enhancing aspects, derived from the observed interaction effects among classroom design elements. Similar distinctions have been discussed in earlier empirical research, such as Herzberg's (1959) concept of *satisfiers* and *dissatisfiers*, and Bluyssen et al.'s (2020) differentiation between *basic requirements* and *positive features*. Both frameworks provide empirical foundations for understanding how environmental and contextual conditions influence human performance and experience. However, rather than adopting these categories directly, the present study applies a similar conceptual logic to the specific context of the data set and the classroom design, aligning the terminology with the dynamic and layered relationships revealed in the data.

The terms *baseline essentials* and *enhancing aspects* were deliberately chosen to build on these existing insights while better reflecting the interactive structure identified in this study. Whereas earlier frameworks classified factors categorically, the distinction proposed here is based on the order of influence observed in the results—showing how one set of factors enables the other.

The distinction between baseline essentials and enhancing aspects is based on their observed role in the data: whether they acted as prerequisites for positive outcomes or as elements that further enhanced outcomes once they prerequisites were met. Elements that showed consistently low scores on student satisfaction, motivation and productivity when absent – regardless of the quality of other design aspects – were classified as baseline essentials. The visible baseline essentials in this study were mainly the furniture ergonomics (C101), the *indoor environmental qualities* (C104) and the *workspace variety* (C102). When these were insufficient or absent in the classroom, overall student satisfaction, motivation and self-perceived productivity remained low regardless of other design qualities, as was seen in classroom 2.04 (school A) were the IEQ scored lower than 2.07 (school A) with a similar setup but higher negative scores on IEQ (C104; r =-0.49**). In contrast, enhancing aspects such as *visual appearance* (C301), *spatial clarity and layout* (C103), *emotional and mental support* (C204) contributed to higher scores primarily when the baseline conditions were already in place, as was seen in classroom 2.01-2.02 (school B) and 0.10 (School B) were the essentials scored higher than at school A.

This distinction was not based on their relative importance, but on their observed order of effect: essentials form the foundation on which enhancing aspects can build further improvements. In other words, these enhancing aspects appear to elevate student learning experiences from adequate to highly positive levels, rather than compensating for the absence of essentials. When essentials are insufficient or lacking, they overshadow other positive qualities; when they are secured, enhancements in less tangible aspects create multiplier effects that elevate the student experience from adequate to highly positive levels.

5.2. Recommendations

Based on the findings, two types of recommendations can be made: (1) recommendations for future research to further develop and validate these insights, and (2) recommendations for educational practice to inform classroom design.

5.2.1. Recommendations for research

Future research should further investigate how the interaction between the baseline essentials and enhancing aspects influence students learning experience. . This study introduces a conceptual distinction similar to that of Bluyssen et al. (2020) and Herzberg (1959), aligning the terminology with the dynamic and layered relationships revealed in the data, rather than adopting categories directly from earlier research. This study had a descriptive-exploratory character and was intended to identify initial patterns, but further validation will require larger-scale case studies. In future work, it is recommended to include a broader and more diverse sample of schools in order to capture a wider variety of classroom settings. Studies could also explore which specific combinations of elements are most effective for different student groups, taking into account factors such as age, learning style and subject domain.

Due to limited time and the small number of participating schools, this study was restricted to a snapshot analysis of five classrooms and a maximum of sixteen design elements observed within the school buildings. Future research is encouraged to move beyond this exploratory scope and adopt longitudinal or

experimental study designs. Such approaches would enable the examination of long-term effects of classroom design on learning outcomes and well-being, rather than focusing solely on short-term perceptions. This would allow future studies to provide more generalisable evidence for the development of design guidelines for secondary school classrooms.

5.2.2. Recommendations for practice

Building on the findings of this study, several implications can be drawn for the design, management, and policy of learning environments. The results show that the quality of classroom design is shaped by the interaction between physical and experiential factors, underscoring the need for design decisions guided by both functional and human-centred principles.

1- Design for both physical and emotional comfort

Architects and facility managers should first secure the *baseline essentials* that form the foundation for all other experiences. Ergonomic furniture, sufficient workspace variety, and high indoor environmental quality are not "luxury" features but prerequisites for satisfaction, productivity and motivation. These factors should be addressed early in the design and renovation process and ideally verified through performance-based methods, such as comfort surveys, daylight analysis, or acoustic measurements, rather than aesthetic judgement alone. Ensuring these essentials provides the stable physical and cognitive foundation upon which learning can thrive.

Beyond these essentials, classroom design quality should be assessed not only through technical metrics but also through its emotional and visual impact on users. Aesthetics, colour, light, and materiality contribute to students' sense of belonging, calm, and motivation. Schools that clearly articulate their educational vision and involve students in identifying what makes them feel supported can define stronger criteria for their *programmes of requirements (PvE)* and design briefs. This enables architects to translate user needs into targeted, meaningful design solutions. In practice, this means recognising the affective and aesthetic experience of the classroom not as a secondary concern but as a central dimension of design quality.

2- Adaptive designing by strengthening collaboration

Effective learning spaces anticipate change and empower their users. Classroom design should anticipate changes in teaching methods, class sizes, and learning preferences. Providing a diversity of spatial options—zones for focus, collaboration, and informal interaction—empowers both students and teachers to use space according to pedagogical needs. For policymakers and school boards, this means supporting modular furniture systems and reconfigurable layouts that can evolve with curricula rather than relying on fixed, one-size-fits-all solutions. Schools that embed flexibility into both their spatial design and organisational practices create environments that remain relevant and efficient over time.

To achieve this, schools, architects, and facility managers should engage in participatory design processes that include both teachers and students. This ensures that spaces reflect actual learning practices and user needs rather than top-down assumptions. Design workshops or co-creation sessions—rather than fixed, pre-defined PvE documents—enable users to actively shape the design of their environment. The quality of a learning space lies not in its visual perfection, but in its ability to respond to educational routines and human experience. Evidence from this study shows that even small, user-informed design adjustments—such as clearer spatial layouts or increased workspace variety—can significantly improve students' daily learning experience.

3- Embedded classroom design in educational policy and performance evaluation

Current policy frameworks, such as the Dutch *Frisse Scholen* programme, already acknowledge the importance of indoor environmental quality and energy performance. While these standards are essential for ensuring healthy and sustainable buildings, they primarily address the physical and technical conditions, overlooking how design affects student's satisfaction, motivation, and productivity.

The findings of this study suggest that to truly enhance the student learning experience, policy should extend beyond these baseline conditions. Frameworks should also recognise spatial, aesthetic, and

emotional qualities—such as flexibility, visual clarity, and students' sense of belonging—as integral dimensions of classroom quality. Ministries, municipalities, and school boards can therefore complement existing technical standards with human-centred design criteria that explicitly link environmental quality to the student learning experience.

These criteria can be made measurable by incorporating *user experience indicators*—such as student satisfaction, perceived productivity, and motivation levels—into evaluation frameworks and design briefs. Regular surveys, observational studies, and participatory feedback sessions can provide systematic data on how spatial and emotional qualities influence learning outcomes. This would turn classroom quality into a continuously monitored and evidence-informed component of educational policy rather than a one-time design outcome.

Importantly, these principles can also be applied before construction or renovation. During the design and planning stages, participatory design sessions, *pre-occupancy surveys*, and *user journey mapping* can be used to anticipate user experience and adjust spatial strategies early in the process. Integrating these feedback loops into the initial design phases, schools, facility managers and policymakers can ensure that learning environments are not only technically compliant but also experientially responsive. In doing so, classroom design becomes part of the broader conversation on educational quality and performance—moving from a purely operational or technical issue to an integrated pedagogical variable. This shift encourages schools and governing bodies to evaluate not only how efficiently space functions, but also *how effectively* it supports learning, motivation, and well-being.

In sum, the findings suggest that effective classroom design requires a balance between functional robustness and emotional resonance. By integrating ergonomic, flexible, and aesthetic dimensions within policy and design practice, stakeholders can move towards classrooms that not only accommodate learning but actively enhance it. To achieve this balance, schools and designers should first secure the baseline essentials, such as comfort, ergonomics, and environmental quality, before introducing enhancing aspects like visual appeal, spatial clarity, and emotional or social support. Once these foundations are in place, such enhancements can elevate student motivation and engagement, as exemplified by classroom 0.10, where flexibility, variety, and strong aesthetics together produced the highest overall learning experience.

A classroom designed according to these recommendations would feature a flexible layout with movable furniture that allows easy transitions between group-based and individual learning activities. Ergonomic chairs and height-adjustable desks would provide physical comfort, while sufficient daylight, good air quality and sound-absorbing materials would provide stable environmental conditions. Clearly defined learning zones would support orientation and focus, offering distinct areas for quiet individual work, collaborative group tasks, and informal social interaction. Personalised display boards and visually engaging wall elements would allow students to make the space their own, contributing to a sense of ownership, engagement and pride. This type of environment combines functional stability, adaptability and atmosphere, reflecting the key insight of this study: successful classroom design depends not on individual features alone, but on the synergy between physical comfort, flexibility, and emotional resonance.

Secure the baseline essentials of comfort and autonomy first, and then build on them with targeted enhancements that address aesthetics, clarity, and support.

5.3. Reliability of the research

Reliability in this study refers to the consistency and transparency of its research design, as well as the stability of its instruments across different contexts. Throughout all phases — from conceptual framing to data collection and analysis — efforts were made to ensure clarity, coherence, and repeatability.

The structure of the student surveys remained consistent across both schools, with the same categories and phrasing used to measure satisfaction, motivation, and productivity. Administering the survey within the actual classrooms, immediately following lessons, ensured a comparable setting and enhanced the uniformity of responses. Moreover, the analytical approach, based on categorised Likert-scale distributions and cross-case comparison, was applied systematically across datasets.

Interviews were conducted using a semi-structured format built around thematic prompts that mirrored survey categories. This design preserved flexibility while still ensuring consistency in the topics explored with each teacher. The case studies themselves followed a parallel descriptive framework to document layout, environmental quality, and spatial logic, allowing for structured comparison despite architectural differences.

What reinforces reliability in this study is not just procedural repetition, but methodological triangulation. Student voices, teacher perspectives, and spatial observations were brought into dialogue, allowing the dataset to cross-validate itself. Where student survey trends aligned with teacher reflections and observable conditions, interpretive consistency strengthened the credibility of the results.

5.4. Limitations and future research

While this study provides robust insights into the relationship between classroom design and the student learning experience, several limitations must be acknowledged.

1) **Sample size and generalisability:** The relatively small sample size (N = 173) increases the risk that correlations appear stronger than they might in a larger, more diverse dataset. The students in this dataset rated their satisfaction, motivation and perceived productivity very similarly (SD = 2.2), indicating that the three mediators were valued in a relatively balanced way. Furthermore, the study relied on self-reported perceptions from a single context (two Dutch secondary schools), which limits the generalisability of the findings. It cannot be ruled out that the construct reflects the characteristics of this specific sample rather than a universally valid relationship. Future studies with larger and more varied samples are therefore necessary to confirm whether satisfaction, motivation and productivity consistently cluster as one construct of student learning experience across different educational contexts.
2) **Gender considerations:** In this study, gender was excluded from the analyses for methodological and ethical reasons (see paragraph 3.3.1). Prior research (Dahlan, 2008; 2012) indicated that mean differences between male and female students were marginal (≈0.1–0.2 points). Combined with the ethical consideration of minimising personal data collection for participants under 18 years, gender was excluded in this analysis. Nevertheless, gender may still shape how students perceive and use classroom environments. Future studies should therefore include gender as a potential moderating variable to examine whether and how male and female students experience classroom design differently.
3) **Self-reported data:** The study relied primarily on self-reported perceptions of satisfaction, motivation, and productivity. While these provide direct insight into student experiences, self-reporting can be subject to biases, such as social desirability or response fatigue. Triangulation with objective measures (e.g., observational data, academic performance, or behavioural tracking) would provide a more comprehensive understanding of how classroom design influences learning outcomes.
4) **Statistical approach and analytical scope:** The statistical analysis in this study was limited to descriptive and correlational methods. This decision aligns with the descriptive-exploratory and perception-based nature of the research, which aimed to identify relationships rather than to

predict or establish causality. While this approach ensures analytical robustness and validity within the context of classroom settings, it restricts the ability to infer causal effects or quantify the strength of influence between variables. Regression or structural equation modelling could, in future studies, provide deeper insights into how specific spatial design factors interact to shape satisfaction, motivation, and productivity. However, such techniques require larger, more controlled datasets and distinct variable independence, which were beyond the scope of the current study.

5) **Situational factors:** The study captured a snapshot in time, which may not fully reflect dynamic classroom indicators or seasonal variations in IEQ (e.g., daylight, temperature, noise). Longitudinal studies could reveal how student learning experiences evolve over the school year and how the impact of design elements persist over time.
6) **Research terms and literature scope:** The literature study relied on a specific set of search terms to identify relevant sources. While these terms were selected to align closely with the research aim, they may also have limited the scope of the findings by excluding relevant studies that used different terminology. The number of sources retrieved was therefore inherently constrained by the chosen search strategy (see Figure 2.6). Future studies are encouraged to apply broader or alternative search terms to capture a wider range of perspectives.
7) **Conceptual categorisation:** The selection of the 16 design elements and their grouping into four categories (essential design elements, supportive design elements, architectural design aesthetics, and functional design elements) was partly based on the researcher's own interpretation of the literature and the observed data patterns. While this framework supported the analysis and helped structure the results, future studies are encouraged to test and validate this categorisation with alternative datasets or frameworks to ensure its robustness and transferability.
8) **Indirect link to academic performance:** While this study focused on satisfaction, motivation, and self-perceived productivity, it did not measure academic performance directly. Literature suggests that these mediators are precursors to achievement (Bluyssen et al., 2020; Barrett et al., 2015). Therefore, future research should explore whether and how improvements in classroom design and use translate into measurable academic outcomes, while being careful not to assume a direct causal link without further evidence.

Taken together, these limitations highlight the importance of broadening the empirical base and diversifying methodological approaches. Future research directions are:

1) Conduct larger-scale studies across multiple schools and regions to validate the integrated construct of the student learning experience and test its generalisability.
2) Combine subjective and objective measures of learning outcomes, including academic performance, engagement metrics, and behavioural observations.
3) Explore longitudinal effects of classroom design improvements to understand how changes in essentials and enhancers influence student experience over time.
4) Include gender as a potential moderating variable in future analyses to explore whether experiences of classroom design differ across male and female students.
5) Broaden the scope of research to examine the influence of other school spaces (corridors, cafeterias, outdoor areas) to understand how the wider school environment contributes to student satisfaction, motivation, and productivity.

By addressing these limitations and extending the scope of research, future studies can further refine evidence-based guidelines for classroom design and management, ensuring that learning environments consistently support holistic student experiences.

Chapter 06. Conclusion

The main research question guiding this study was: ***How does the design and use of classroom environments influence the learning experience of secondary school students?***

This research demonstrates that the classroom environment is far more than a static backdrop for education; It is an active and decisive environment that fundamentally shapes the learning experience of students. By combining insights from literature, case study observations, student surveys, and teacher reflections, it becomes evident that both the design and the use of classrooms significantly influence how students feel, behave, and perform in their daily learning experience.

The literature review revealed that classroom environments are most comprehensively understood through the interplay of three perspectives: the educational, the pedagogical, and the spatial. These perspectives are closely interwoven: the educational perspective defines the curricular ambitions, the pedagogical perspective translates them into teaching approaches, and the spatial perspective must enable these ambitions in practice. Initially, the four design categories appeared to align with these perspectives, but the individual design elements often cut across them. For example, workspace variety enables diverse pedagogical formats such as group work or individual study (pedagogical), supports differentiated instruction aligned with curriculum goals (educational), and relies on spatial zoning and layout design (spatial). This interdependence confirms that classroom design quality must always be evaluated through its integrated, not isolated, dimensions.

To give structure to these insights, Dahlan's model (2008) was critically adapted to the context of nowadays Dutch secondary schools. This refinement resulted in a framework of four categories: Essential Design Elements, Supportive Design Elements, Architectural Design Aesthetics, and Functional Design Elements, covering sixteen aspects in total. Combined with the identification of satisfaction, motivation, and productivity as indicators of the student experience, this framework provided a robust foundation for the empirical analysis.

While all four categories contribute to the overall student learning experience, the empirical analysis revealed several highly significant correlations between the design and use elements and the student learning experience, and especially high positive correlations with emotional and mental support (C204), visual appearance (C301) and workspace variety (C102). At the same time, both the survey and interviews confirmed that certain elements, such as ergonomic furniture (C101), layout and spatial logic (C103), and indoor environmental quality (C104), acted as baseline essentials and non-negotiable conditions for a positive student learning experience. When these essentials were present, classrooms were perceived as supportive and enabling; when they are lacking, as observed in Classroom 2.04 (school A), satisfaction, motivation, and productivity scored lower—even when other design qualities such as aesthetics or spatial clarity were present.

These findings underline a clear hierarchy: secure the essentials of comfort and autonomy first, and only then build on them with targeted enhancements that address aesthetics, emotional support, and functional clarity. Teachers confirmed this interpretation, emphasising that when baseline conditions fail, pedagogical opportunities are restricted, and engagement is compromised. As on teacher stated: *'you don't adapt your lesson to the classroom, but you let the classroom adapt to your lesson'*.

Moreover, the statistical analysis showed that satisfaction, motivation, and productivity are not separate or independent outcomes, but highly correlated [r= 0.80-0.82] and interwoven dimensions of a single construct: the *student learning experience*. This finding strengthens the argument that classroom design and use should not be evaluated on fragmented outcomes, but on their integrated effect on the overall student experience.

Classroom 0.10 (school B) exemplified this balance. It achieved the highest overall mean score [M=8.0] and the strongest positive correlation with student learning experience, because it combined strong essentials with flexibility, workspace variety and a coherent visual engagement. Rather than representing an "ideal classroom," it serves as a context-specific exemplar that demonstrates how balance and synergy between physical and experiential factors can elevate learning quality, while the optimal balance may vary

across schools and user groups. Conversely, classrooms with the lower, but still positive, overall scores in this study [M≈ 6.0] can be characterised as adequate but constrained. They generally provided the (weaker) basic essentials but lacked enough value-adding elements to elevate the overall experience, reinforcing that design and use are mutually dependent: design enables use, and use activates design. A technically well-designed classroom loses its impact if not used in alignment with pedagogical practices, while even the most innovative teacher is constrained by poor environmental quality or inflexible layouts. Future management of classrooms must therefore balance comfort, flexibility, aesthetics, and functionality, ensuring continuous alignment between spatial design and educational ambition.

These findings translate directly into practical recommendations for architects, educators, and policymakers. Schools and designers should first secure the baseline essentials and then the enhancing elements as prerequisites for optimising the student learning experience. Participatory design processes involving teachers and students, and performance-based evaluation tools such as comfort surveys or post-occupancy feedback, can ensure that classroom environments remain responsive to changing pedagogical needs. Finally, educational policy frameworks should expand beyond technical standards to include spatial, aesthetic, and emotional criteria, linking classroom quality directly to student experience and motivation.

In conclusion, this study shows that the design and use of classroom environments have a direct and measurable influence on the learning experience of secondary school students. As already argued by the Italian pedagogical Loris Malaguzzi in the 1940s, the classroom should be recognised not as a passive backdrop but as the “third teacher”: a central actor in the educational process. By securing essential conditions and building thoughtfully upon them, schools can create environments that not only accommodate learning but actively enrich it—enabling students to thrive in both engagement and achievement.

The insights from this study do not offer a fixed blueprint, but they outline a structured way of thinking about classroom design that starts from securing the essentials and then layering supportive, aesthetic and functional elements on top. A classroom designed from the perspective of this study would first provide physical comfort and stability through ergonomic furniture, clear spatial organisation, and a healthy indoor climate. Within this stable foundation, flexible layouts and movable furniture would allow seamless transitions between group-based and individual learning activities. Distinct learning zones would support orientation and focus, while personalised display boards and visually engaging wall elements would foster a sense of ownership and motivation. Such a classroom combines functional stability with adaptability and personal relevance, enabling students to feel comfortable, engaged, and able to perform at their best. These insights can help schools, architects and policy makers to evaluate existing spaces and to make design choices that are both context-sensitive and evidence-informed, rather than ad hoc or purely aesthetic.

Chapter 07. Reflection

This chapter delves into the reflection on the product, process, and personal development during this graduation thesis: “The Impact of the Classroom Environment”.

7.1. Product

Graduation topic within the master track

The research project, titled: “The impact of the Classroom Environment”, is conducted as a graduation project within the master track Management in the Built Enviroment (MBE) at the Faculty of Architecture and the Built Environment at TU Delft. The research topic aligns directly with the studio’s guiding theme “value and evaluation” within CRE. The research explores how the physical design and use of classroom environments influence the student learning experience. It specifically investigates the value of learning environments from the user’s perspective and translates these insights into recommendations for the spatial design and strategic management of educational real estate.0

The relevance of this topic within the MBE track lies in its integration of user-centric design strategies and the strategic management of real estate assets. By analysing the classroom as both a physical and experiential environment, the research contributes to a deeper understanding of how real estate decisions can support institutional goals while simultaneously enhancing student learning experience. It bridges the domains of real estate development and educational policy, demonstrating how added value in public assets can be achieved not solely through efficiency, but through holistic, experience-based design.
The relevance of this topic within the programme level, the MSc in Architecture, Urbanism and Building Sciences (AUBS), lies in its interdisciplinary perspective to tackle spatial, organisational, and social challenges in the built environment. This project reflects that ambition by combining architectural theory, empirical data collection, behavioural analysis, and real estate strategy. It highlights how spatial design can function as a strategic tool for value creation in learning environments, advancing both academic knowledge and practical applicability.

Scientific relevance and societal value

Scientifically, the research contributes to the growing interdisciplinary discourse on the mediating role of the built environment in educational contexts. While many studies have examined technical parameters such as lighting or acoustics in isolation, this thesis introduces a more integrated, user-centred approach by focusing on the *student learning experience*. It offers empirical support for theoretical frameworks that focus on improving the student experience within educational settings.

From a societal perspective, the project responds to a pressing and practical concern: how can school buildings be designed or adapted to better serve the learning needs of the students? In light of evolving education and spatial obsolescence in the Dutch secondary school system, this research offers concrete recommendations for schools, architects, and policymakers. It provides actionable insights into how the learning environment, and especially the classroom environment, can improve the student learning experience.

Scope and implications of the graduation project

The scope of this research is limited to examining the influence of classroom design and use on secondary school students’ learning experience, measured through satisfaction, motivation, and self-perceived productivity. The study focused on five classrooms in two Dutch secondary schools, using student surveys and teacher interviews to assess how different spatial and functional elements contribute to the student experience. While the analysis provides empirical evidence for both essential and enhancing factors of classroom quality, it does not claim to capture all possible influences, such as broader institutional or socio-cultural contexts.

The implications of the project extend beyond the immediate case study. The findings demonstrate that classroom environments shape student experiences holistically and that securing baseline essentials (e.g., ergonomics, workspace variety, IEQ) is a prerequisite for positive outcomes. When complemented

with enhancing factors (e.g., spatial clarity, aesthetics, emotional support), these essentials can generate multiplier effects on the student learning experience, and especially their satisfaction, motivation, and productivity. For school managers and policymakers, this implies that classroom design and management should be approached as a strategic tool for supporting student well-being and engagement, thereby increasing the long-term value of educational real estate.

Ethical considerations

Given the nature of this research, investigating student perceptions and experiences within classroom environments in secondary education, ethical considerations were a central concern throughout the project. The study involved data collection from minors (aged 16+), which required careful adherence to ethical protocols to ensure the protection, anonymity, and dignity of all participants.

Prior to commencing any fieldwork, the research proposal underwent formal review and received approval from the Human Research Ethics Committee (HREC) of TU Delft. This approval process included a comprehensive review of a HREC checklist outlining potential risks, mitigation strategies, and ethical safeguards specific to the research context. In addition, a detailed Data Management Plan (DMP) was developed in compliance with TU Delft's data governance framework, ensuring that all collected data was securely stored, anonymised, and used solely for academic purposes. As part of the ethical protocol, all participating students and interviewees (teachers) received informed consent forms explaining the aim, scope, and voluntary nature of the study. Participants were given the opportunity to withdraw at any stage without consequence, and their responses were treated with strict confidentiality.

Further, due to the processing of personal and potentially sensitive information, a Data Protection Impact Assessment (DPIA) was conducted, and approval was obtained from the Privacy-TUD team. This additional layer of review ensured full compliance with GDPR regulations and the university's internal privacy policies. No personally identifiable data was collected, and all qualitative input was anonymised during transcription and analysis. Altogether, these ethical procedures ensured that the study met high standards of integrity, transparency, and participant welfare. Ethical responsibility was not only seen as a procedural obligation but as an essential dimension of conducting socially engaged and human-centred research.

Transferability of project results

While the empirical data of this study is rooted in two specific case studies within Dutch secondary education, and the explatory character of the research, the conceptual framework and key findings are broadly applicable and relevant to educational contexts beyond the initial scope. The central premise that spatial quality, as perceived by students, has a measurable impact on motivation, satisfaction, and self-perceived productivity can be adapted and replicated in a variety of educational settings.

The transferability of this research is further reinforced by the practical relevance expressed by stakeholders during the fieldwork phase. The participating schools demonstrated strong enthusiasm for the project and were genuinely interested in both the process and the outcomes. Teachers, school leaders, and even facility managers of the school boards indicated that the findings reflected existing yet underarticulated challenges within their own environments. Several school boards with whom preliminary discussions were held shared this sentiment. They acknowledged that the topic of spatial experience and its connection to their students learning experience is highly relevant yet insufficiently addressed—particularly in the context of developing Programmes of Requirements (PvE / PoR) for new school buildings or major renovations.

Many indicated that while they are aware that their learning environments are outdated or misaligned with modern pedagogical practices, they often lack the tools, frameworks, or evidence-based criteria to guide meaningful improvements. This research was therefore seen as a valuable stepping stone for initiating more user-oriented, evidence-informed spatial strategies in the design and management of learning environments.

Consequently, the outcomes of this study not only inform academic discourse but also encourage a more structured way of thinking about classroom design for architects, policymakers, and educational facility managers. Instead of offering a fixed set of design rules, this study proposes an approach that begins with securing baseline essentials and then thoughtfully layering supportive, aesthetic, and functional elements on top. The survey framework and conceptual model developed can serve as a tool to evaluate existing classroom environments or as input for stakeholder dialogues during the early stages of school development projects. By bringing the student perspective to the forefront, the project fosters a more inclusive and responsive approach to educational real estate planning - one that aligns spatial ambitions with actual educational experiences.

7.2. Process

Looking back, the process of conducting this research was both intellectually demanding and personally transformative. What began as a structured and well-defined plan evolved into a dynamic journey filled with unexpected turns, challenges, and valuable lessons.

Methodology & Data collection

At the beginning, I knew that I wanted to place the student perspective and the educational real estate at the core of my study, due to my own observations in this field of work. This decision naturally led me to a mixed-methods approach, combining student surveys with teacher interviews. This approach felt like the right methodological match for my ambition: to uncover not just what learning environments look like, but how they *feel* and *function* from the user's point of view.

The research initially aimed to have a qualitative core, using focus groups and interviews to explore the learning experience of secondary school students. However, due to limited interest and availability within this target group, the focus shifted towards the survey as the main method of data collection, making the research quantitative as the core. Organising focus groups proved challenging, as many students didn't want to participate and the schools indicated that they couldn't participate within the available time frame. Schools that were initially willing to participate were mostly MAVO schools, but these were excluded because their students were under 16 years old. This made it more difficult to find the right cases for this study. Other schools caused substantial delays by either declining to participate or not responding within a reasonable time, which further hindered the progress of the research. This was one of the most challenging parts of the research: finding the right case and wanting them to participate.

Also, a challenging part in the research was translating static architectural elements into measurable constructs, and abstract concepts such as *student satisfaction*, *motivation*, and *productivity* into survey questions that were both easy to understand and meaningful for secondary school students. Working with minors also forced me to look differently to a survey then when surveying adults. By collaborating with teachers—who introduced the purpose of the survey before administering it at the end of a lesson—I was able to secure thoughtful and engaged responses. This method not only improved the quality of the data but also significantly increased the response rate.

Designing and analysing the survey proved to be the most complex yet also the most insightful and, truthfully, the most enjoyable part of the study. It was inspiring and energising to see how students described their daily learning environments, and how clearly patterns began to emerge in their perceptions while analysing. The teacher interviews added an essential second layer, providing context, triangulation, and alternative interpretations to the survey results.

What ultimately made this approach effective was the layered manner in which each method addressed different aspects of the research questions. The surveys offered breadth and quantifiable patterns; the interviews added depth, interpretation, and nuance. Supported by an extensive literature review, these data sources formed a coherent whole that enabled me to answer the main research question with confidence. This methodological structure allowed me not only to collect valuable data, but to tell a story that was grounded, multidimensional, and user informed.

Navigating limitations

A significant and somewhat unexpected challenge emerged regarding the link to academic performance. Although I initially intended to connect students' reported experiences to their actual grades, this was not possible due to ethical considerations surrounding the use of sensitive performance data. This was disappointing, as it had been a clear starting point and aspiration for the project. Literature consistently underlines the potential relationship between classroom environments and academic performance, and I had hoped to test this empirically. However, without access to such data, this aspect could not be validated within my study.

Instead, I focused on three reliable and ethically responsible indicators: student satisfaction, motivation, and self-perceived productivity. While these may be considered proxies rather than direct measures of performance, they nonetheless offered valuable insights into how students experience and evaluate their learning environments. In retrospect, what first appeared to be a limitation ultimately sharpened the focus of the study, aligning it more strongly with my original aim of centring the student voice.

When looking back, I am genuinely proud of the results that emerged from this methodological approach. Although it was not possible—due to ethical considerations—to compare the outcomes directly with students' actual academic performance (e.g., grades), the descriptive-exploratory nature of the research nonetheless allowed for meaningful conclusions. The findings clearly indicate that the *design and use* of the classroom environment play a significant and non-negligible role in shaping students' satisfaction, motivation, and self-perceived productivity. This insight not only validates the approach but also underscores the importance of considering spatial quality as an active factor in the student learning experience.

This methodological journey taught me the importance of flexibility and resilience in research. Plans inevitably change, and constraints—whether ethical, practical, or methodological—can redirect the focus in meaningful ways. The exclusion of academic performance, for example, forced me to think more critically about what could be measured, and led me to develop a framework grounded in user perception rather than outcomes alone.

Lessons learned

Looking back, several key lessons emerged from conducting this graduation research:

1- **Embrace flexibility and adaptivity in research design:** What began as a structured plan with a qualitative core had to be adapted along the way, due to limited participation from the target group and time constraints at the schools. Switching from focus groups to a survey-based approach initially felt like a setback, but ultimately strengthened the study by enabling the collection of broad, quantifiable data. This taught me that flexibility is not a weakness but a crucial skill in research — it allows the project to stay aligned with its objectives even when conditions change.

2- **Prioritise methodological feasibility without losing conceptual depth:** Balancing conceptual ambition with practical feasibility was one of the greatest challenges. Translating static architectural elements and abstract concepts (like satisfaction or motivation) into measurable constructs suitable for minors required careful operationalisation and iterative testing. Collaborating with teachers to introduce the survey proved essential, both ethically and methodologically, as it secured engaged responses while respecting participants' needs.

3- **Ethical constraints can sharpen focus:** The inability to link students' experiences to actual performance data (e.g. grades) felt like a limitation at first. In hindsight, it forced me to refine the study's focus and commit to the student perspective as the primary lens. By doing so, the project stayed ethically sound while still offering valuable and actionable insights — a reminder that ethical boundaries are not barriers, but guideposts for responsible research.

4- **Research is iterative and human:** Perhaps the most personal lesson is that research rarely unfolds as planned — and that is part of its value. This project demanded resilience, openness, and the willingness to rethink assumptions. It showed me that meaningful outcomes arise not from rigidly following an initial plan, but from navigating uncertainty with curiosity and integrity.

7.3. Personal experience

Looking back on my graduation project, it was without doubt one of the most demanding and enriching journeys of my academic career so far. What began as a personal curiosity*: how the learning environments affect students' daily experience,* grew into a comprehensive, layered research process that challenged me on intellectual, emotional, and organisational levels.

One of the most rewarding aspects was being able to work directly with students and teachers. Being physically present in the classrooms for the observations, analysing student responses that revealed frustrations and appreciation for specific spatial aspects, and listening to teachers reflect on how space shapes the learning process - these were the moments that made the research feel real and purposeful. They reminded me of why I chose this topic in the first place.

But it wasn't always easy. The process demanded a great deal of flexibility and patience, particularly due to setbacks in case recruitment. Several schools declined participation or didn't respond at all, which caused delays and forced me to rethink timelines and strategy. The long waiting periods for the cases and surrounding ethical approvals from the DPIA also tested my patience and perseverance. These moments taught me to let go of rigid expectations and instead adopt a more adaptive mindset. I learned to trust the process, even when it became difficult from time to time. I tried to stay flexible without compromising quality and keep the bigger picture in view - even when the path forward was unclear.

At times, this was personally the most difficult part for me. I still remember one of my first meetings with my graduation mentors right after the P2 phase. I was so fully immersed in the technical aspects of the project that my mentor had to pause me and simply ask, *"But how are you doing?"* That question caught me off guard and made me realise I had lost sight of why I started this project in the first place, namely, the believe in the power of educational space to shape student experiences, motivation, and growth. Not just as a technical problem, but as a human one. An aspect that we sometimes forget during work meetings in practice, regarding educational buildings.

Another particularly challenging moment came when I had to retake my P4. At first, this felt like a heavy setback. I had worked hard to deliver within a limited timeframe and struggled with the idea of starting over. It made me doubt my approach and it was difficult for me to understand how and why it happened. Fortunately, the encouragement of others reminded me of what I was striving for and helped me regain perspective. I learned that resilience is not about avoiding failure, but about continuing with intent – even when things feel uncertain or discouraging.

A further limitation I faced was the inability to collect actual academic performance data, such as grades, due to strict privacy and ethical restrictions. This was initially frustrating, as connecting spatial experience to measurable outcomes had been one of my ambitions. Yet, it pushed me to focus more deeply on the proxies of satisfaction, motivation, and self-perceived productivity. In hindsight, this constraint helped me to strengthen the student perspective at the core of the project, ensuring that their voices remained central.

Throughout the project, my graduation supervisors played a crucial role in helping me stay on course. Their clear guidance in the design of the research set a strong foundation, and their consistent encouragement kept me motivated, especially when finding case studies proved difficult and the P4 resubmission. I came to understand that resilience in research is not about maintaining constant control, but about remaining committed to progress despite obstacles.

I've learned a great deal about how educational buildings function and what factors are often overlooked in practice. It became clear to me that in many school projects, spatial experience is not always consciously considered, yet it plays a significant role in how students learn and experience. I now feel far more confident and equipped to bring this awareness into future real estate or design projects. I hope to use these insights in my professional practice, where I can advise clients on ERE; knowing what to look for, and what often goes unseen, is a perspective I will carry with me.

On a personal level, I developed important skills in independent working and managing complexity. Over the past year, I was continuously working on balancing data collection, analysing, writing, and continuous critical reflections, which forced me to adopt a structured, yet flexible way of working. Over time, I became

more confident in decision-making, more aware of my academic voice, and better at translating abstract ideas into concrete, researchable insights.

Above all, I am proud that I stayed true to the essence of the research. Despite setbacks and moments of doubt, I tried to keep the student perspective at the centre of the study, an aspect still too often absent in educational literature. I learned that meaningful research is not just about collecting data and writing conclusions; it's about asking the right questions, remaining open to the unexpected, and having the humility to adapt along the way.

On a broader level, this experience deepened my understanding of the societal role of the built environment. I now see buildings not just as static, technical, or economic structures, but as lived and interpreted spaces that shape daily life. Especially in education, where space intersects with identity, focus, well-being, and development - design and management decisions carry real weight. That is a responsibility I take seriously, and one I intend to honour in my future work.

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Appendices

Appendix 1 – STATISTICAL RESULTS

Label (N=173)	*Items (#)*	*Mean (1-10)*	*Standard deviation*	*Cornbach's Alfa (α)*	*Inter-item Correlation*
Mediators	**3**	**6.7**	**2.2**	**0.90**	**0.81**
Satisfaction	1	7.0	2.1	-	-
Productivity	1	6.6	2.1	-	-
Motivation	1	6.3	2.3	-	-
Design characteristics	**4**				
Essential Design Elements	**4**	**6.3**	**2.2**	**0.83**	**0.62**
C101	1	6.0	2.2	-	-
C102	1	5.9	2.5	-	-
C103	1	6.3	1.9	-	-
C104	1	6.9	2.1	-	-
Supportive Design Elements	**4**	**7.0**	**1.8**	**0.82**	**0.55**
C201	**1**	6.7	1.9	-	-
C202	**1**	7.3	1.6	-	-
C203	**1**	7.2	1.9	-	-
C204	**1**	7.0	1.7	-	-
Architectural Design Aesthetics	**4**	**6.9**	**1.8**	**0.84**	**0.58**
C301	1	6.5	1.7	-	-
C302	1	7.1	1.9	-	-
C303	1	7.1	1.8	-	-
C304	1	7.1	1.8	-	-
Functional Design Elements	**4**	**6.6**	**1.9**	**0.84**	**0.57**
C401	1	6.8	2.0	-	-
C402	1	6.6	1.8	-	-
C403	1	7.0	1.7	-	-
C404	1	6.4	2.0	-	-

Descriptive of mediators and design characteristics (N=173)

Label (N=173)	*Items (#)*	*Mean (1-10)*	*Standard deviation*
Classroom 2.04	**3**	**5.8**	**2.6**
Satisfaction	1	6.0	2.6
Productivity	1	5.9	2.6
Motivation	1	5.4	2.6
Classroom 2.07	**3**	**6.0**	**1.7**
Satisfaction	1	6.5	1.5
Productivity	1	6.2	1.4
Motivation	1	5.6	1.9
Classroom 2.15	**3**	**6.0**	**2.0**
Satisfaction	1	6.5	1.9
Productivity	1	5.7	1.9
Motivation	1	5.8	2.1
Classroom 0.10	**3**	**8.0**	**1.7**
Satisfaction	1	8.2	1.7
Productivity	1	7.9	1.6
Motivation	1	7.9	1.9
Classroom 2.01-2.02	**3**	**7.8**	**1.6**
Satisfaction	1	8.4	1.2
Productivity	1	7.4	1.6
Motivation	1	7.6	1.9

Descriptive of mediators and classrooms (N=173)

Appendix 2 – Dahlan's categorisation (2008)

Classroom Essential Design Elements		No.
Which are necessary to perform teaching and learning process	Teacher Desk & Chair	1
	Adequacy of students chairs	2
	Students writing boards	3
	Blackboard	4
	Blackboard pens and eraser	5
	Electronic blackboard	6
	Audio facilities	7
	Visual facilities (Data Show)	8
	Television	9
	DVD	10
	Adequacy of space in relation to No. of Students	11
	Personal computer for each student	12
	Personal computer for teacher	13

Table 3 | Classroom Essential Design Elements according to Dahlan (2008) [Source: Dahlan (2008), Page 16]

Classroom Supportive Design Elements		No.
Which enhances teaching and learning process	Student's lockers in classrooms	1
	Cleanness of classrooms	2
	Outdoor space per classroom or group of classrooms	3
	Fire and safety systems & equipment's	4
	Natural light	5
	Artificial light	6
	Students' accessibility to control artificial light level	7
	Students' accessibility to control natural light level	8
	Internet connectivity (Cable)	9
	Internet connectivity (Wireless)	10
	Air conditioning	11
	Students' accessibility to control air temperature level	12
	Outdoor Noise level	13
	Quality of artificial air ventilation	14
	Quality of natural air ventilation	15
	Students' accessibility to control air ventilation level	16
	Emergency services Tell. No. Visible in classroom	17
	Emergency escape diagram	18
	University public services Tell. No. Visible in classroom	19
	Lectures timetable near each classroom door	20
	Signboard inside each classroom	21
	Classroom management software	22

Table 4 | Classroom Supportive Design Elements according to Dahlan (2008) [Source: Dahlan (2008), Page 18]

Classroom Accessibility Design Elements		No.
Which are necessary to perform teaching and learning process	Classroom accessibility	1
	Proximity to pray area	2
	Proximity to toilets	3
	Use of classrooms after lectures hours	4
	Signboards for classroom numbers	5
	Individual classroom number	6
	Clarity of classrooms entrances	7
	Adequacy of classrooms entrances	8
	Size of classrooms entrances	9
	Entrance hall for each classroom	10
	Ease of circulation inside classrooms	11
	Emergency exit for each classroom	12
	Signboards for emergency exit in classrooms	13
	Security door lock system	14
	Emergency escape diagram in each classroom	15

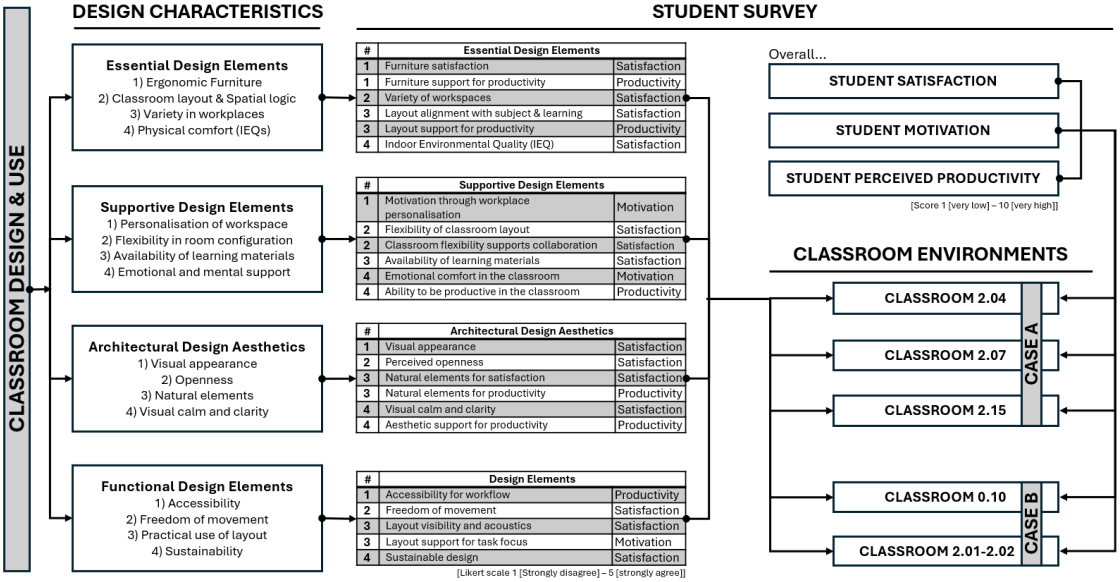
Table 5 | Classroom Supportive Design Elements according to Dahlan (2008) [Source: Dahlan (2008), Page 19]

Classroom Architectural Design Aesthetics		No.
Which are necessary to perform teaching and learning process	General classrooms design aesthetics	1
	Walls colours	2
	Ceiling colours	3
	Floor colours	4
	Walls finishes material	5
	Ceiling finishes material	6
	Floor finishes material	7
	Artificial interior plants	8
	Natural interior plants	9
	Frequent plants maintenance	10
	Outdoor visibility from inside classrooms	11
	Satisfactory visibility from inside classrooms	12

Table 6 | Classroom Architectural Design Aesthetics according to Dahlan (2008) [Source: Dahlan (2008), Page 21]

Appendix 3 – SURVEY QUESTIONS & CITATIONS

3a. Link design and use elements to questions & mediator:



3b. ONLINE SURVEY QUESTIONS STUDENTS

The survey was conducted in Dutch:

Beste leerling,
Je wordt uitgenodigd om deel te nemen aan een onderzoek met als titel *"De impact van onderwijshuisvesting op het verbeteren van de schoolprestaties."* Dit afstudeeronderzoek wordt uitgevoerd door Beyza Tokyay (BSc) als onderdeel van een masterthesis aan de Technische Universiteit Delft (TU Delft).

Het doel van dit onderzoek is om inzicht te krijgen in hoe onderwijshuisvesting en de leeromgeving invloed hebben op de schoolprestaties en tevredenheid van middelbare scholieren. Door dit beter te begrijpen, kunnen scholen in de toekomst slimmer en meer leerlinggericht worden ontworpen.

Deelname houdt in dat je een korte vragenlijst invult van ongeveer 10 minuten. De vragen gaan over jouw ervaringen met de leeromgeving en hoe jij denkt dat die invloed heeft op je schoolprestaties. Je antwoorden zijn volledig anoniem en worden uitsluitend gebruikt voor dit onderzoek.
Deelname is volledig vrijwillig. Je mag op elk moment stoppen of een vraag overslaan. Mocht je na het invullen toch niet meer mee willen doen, dan kun je je antwoorden binnen 14 dagen intrekken. Als je vragen hebt of meer informatie wilt, neem dan gerust contact met mij op via de onderstaande gegevens.

Hartelijk dank voor je overweging om deel te nemen aan dit onderzoek. Je tijd en input worden zeer gewaardeerd.

Met vriendelijke groet,

Beyza Tokyay
Technische Universiteit Delft - Faculty of Architecture and the Built Environment | Projectmanager onderwijshuisvesting.

Clicking through the survey constitutes agreement with the Opening Statement

- I agree*

Sectie 1:

Q1.1. In welk leerjaar zit je?

- 4 Havo
- 4 Vwo
- 5 Havo
- 5 Vwo
- 6 Vwo

Q1.2. Krijg jij les in klaslokaal X?

- Ja, ik krijg les in klaslokaal X.
- Nee, ik krijg geen les in klaslokaal X.

Start block: Mediators & classroom
For the following questions you need to rate the statement between 1 and 10.

Q2.1. Hoe tevreden ben je met klaslokaal X?
- Rating between 1 – 10

Q2.2. Kan je uitleggen waarom?
- Open question.

Q2.3. Hoe goed kun je leren in klaslokaal X?
- Rating beween 1- 10

Q2.4. Hoe gemotiveerd ben je in klaslokaal X?
- Rating between 1-10

End of block

Start block: Essential design elements
For the following questions: Please fill in to what extent, you agree or disagree with the statements about this specific element. Options: Highly disagree till highly agree [1-5]:

Q3.1. Het meubilair (stoelen en tafels) in het klaslokaal is comfortabel.
Q3.2. Het meubilair (stoelen en tafels) helpt mij om langer productief te blijven.
Q3.3. Het klaslokaal biedt verschillende soorten wekplekken aan waardoor ik goed kan werken (bijv. individuele werkplekken en groepswerkplekken).
Q3.4. De inrichting van het lokaal ondersteunt de les en mijn manier van leren.
Q3.5. De inrichting van het lokaal zorgt ervoor dat ik me kan concentreren.
Q3.6. Het binnenklimaat (temperatuur, geluid, luchtkwaliteit en licht) in mijn lokaal zorgt voor een pretige leeromgeving.

Q3.7. Hoe sterk denk je dat bovengenoemde elementen jouw leerprestatie beïnvloeden?
- Rating between 1-10

The options of the following question must be arranged in the correct order from most to least important.
Q3.8. Welk aspect van het klaslokaal ondersteunt volgens jou het meest je leerproces?
- Comfortable stoelen en tafels (1)
- De inrichting van het klaslokaal (2)
- Mogelijkheden tot verschillende plekken om te werken (in groepen of alleen) (3)
- Fijn binnenklimaat: prettige temperatuur, frisse lucht, geen geluidsoverlast en goed licht (4).

End of block

Start block: Supportive design elements
For the following questions: Please fill in to what extent, you agree or disagree with the statements about this specific element. Options: Highly disagree till highly agree [1-5]:

Q4.1. Doordat ik mijn werkplek kan aanpassen of kiezen werk ik gemotiveerder.
Q4.2. Door de inrichting van het klaslokaal kan ik goed samenwerken met klasgenoten.
Q4.3. Alle materialen die ik nodig heb om goed te werken staan in het lokaal (bijv. whiteboards, schermen, digitale tools, etc.).
Q4.4. We kunnen de opstelling makkelijk veranderen voor verschillende activiteiten (bijvoorbeeld presentaties, groepswerk of individueel werk).
Q4.5. Ik voel me op mijn gemak in dit lokaal.
Q4.6. Ik kan me goed concentreren in dit lokaal.

Q4.7. Hoe sterk denk je dat bovengenoemde elementen jouw leerprestatie beïnvloeden?
- Rating between 1-10

The options of the following question must be arranged in the correct order from most to least important.
Q4.8. Welk aspect van het klaslokaal ondersteunt volgens jou het meest je leerproces?
- Personalisatie van je leerplek (1)
- Flexibiliteit van de inrichting (2)
- Beschikbaarheid van leermiddelen (3)
- Mentale en emotionele ondersteuning (4).

End of block

Start block: Architectural design aesthetics
For the following questions: Please fill in to what extent, you agree or disagree with the statements about this specific element. Options: Highly disagree till highly agree [1-5]:

Q5.1. De kleuren en decoratie in het lokaal maken het een fijne plek om te leren.
Q5.2. De uitstraling van het lokaal helpt mij om beter te concentreren.
Q5.3. Omdat het lokaal open en ruim is, kan ik me beter concentreren.
Q5.4. Natuurlijk daglicht en planten in het lokaal maken het lokaal fijner om in te werken.
Q5.5. Natuurlijk daglicht en planten in het lokaal verbeteren mijn concentratie.
Q5.6. Het lokaal is overzichtelijk en rustig ingericht.

Q5.7. Hoe sterk denk je dat bovengenoemde elementen jouw leerprestatie beïnvloeden?
- Rating between 1-10

The options of the following question must be arranged in the correct order from most to least important.
Q5.8. Welk aspect van het klaslokaal ondersteunt volgens jou het meest je leerproces?
- Motiverende uitstraling (1)
- Openheid van de ruimte (vloeiende ruimte om te werken en bewegen (2)
- Natuurlijke elementen (planten en daglicht) (3)
- Visuele rust (opgeruimd en overzichtelijk) (4).

End of block

Start block: Functional design elements
For the following questions: Please fill in to what extent, you agree or disagree with the statements about this specific element. Options: Highly disagree till highly agree [1-5]:

Q6.1. Ik kan door het klaslokaal bewegen zonder andere klasgenoten te storen.
Q6.2. Omdat het lokaal goed toegankelijk is, kom ik sneller in een goede werkflow.

Q6.3. De inrichting van het klaslokaal helpt me om de docent goed te kunnen zien en horen.
Q6.4. Door hoe het lokaal is ingericht, voel ik meer betrokken bij de les.
Q6.5. De duurzaam inrichting (bijv. lichtsensoren en duurzame materialen) maken het lokaal fijner om in te werken.

Q6.6. Hoe sterk denk je dat bovengenoemde elementen jouw leerprestatie beïnvloeden?

- Rating between 1-10

The options of the following question must be arranged in the correct order from most to least important.
Q6.7. Welk aspect van het klaslokaal ondersteunt volgens jou het meest je leerproces?

- Toegankelijkheid klaslokaal (1)
- Bewegingsvrijheid klaslokaal (2)
- Gebruik van het klaslokaal (3)
- Duurzaam ingericht klaslokaal (4).

End of block

Start block: Thematiek
Q7.1. Welk thema ondersteunt volgens jou het meest je leerproces?

- Thema groen: basiselementen
- Thema blauw: ondersteunende elementen
- Thema oranje: Esthetiek & uitstraling
- Thema rood: Functioneel gebruik

Q7.2. Heb je nog verdere opmerkingen of aanbevelingen over deze 4 thema's?

- Open question

Q7.3. Wat zou je graag willen terugzien in je klaslokaal dat je nu mist?

- Open question

End of block

Start block: Bedankt & vervolgonderzoek
Bedankt voor het invullen van deze vragenlijst! Je mening is waardevol en helpt ons om klaslokalen beter af te stemmen op hoe jij het beste leert.

Q8.1. Zou je eventueel mee willen doen aan een vervolgonderzoek, zoals een groepsgesprek (focusgroep) om je ervaringen verder toe te lichten?

- Ja, ik wil meedoen en laat graag mijn e-mailadres achter.
- Nee, liever niet.

End of block

Start block (optional): Vervolgonderzoek
Hartelijk dank voor je interesse! Het vervolgonderzoek zal een kort groepsgesprek zijn met medestudenten over jullie leeromgeving. Precieze data volgt nog.

Q9.1 Ja ik wil meedoen en laat graag mijn e-mailadres achter:

- Open question

End of block

3c. STUDENT QUOTES FROM SURVEY (DUTCH ORIGINAL):

Student A, 0.10: *"A very pleasant and open classroom with comfortable seating options and great for collaboration." – Student A, 0.10*
Dutch original: "Erg fijn en vrij lokaal met comfortabele zitruimtes naar keus en goed voor samenwerken"

Student B, 0.10:*: "It makes the lessons more enjoyable to watch and easier to pay attention." – Student B, 0.10*
Dutch original: "Het maakt het leuker om naar de les te kijken en op te letten."

Student C, 0.10: *"The furniture here is much more comfortable, I can really find a good spot to work." – Student C, 0.10*
Dutch original: "Het meubilair hier is veel comfortabeler, ik kan echt een fijne plek vinden om te werken."

Student D, 0.10: *"It is nice that you can work and sit together with other students, because it feels more pleasant than sitting in a fixed pair. It feels as if you have more freedom in class while still being able to pay attention to the teacher." – Student D, 0.10*
"Het is fijn dat je samen met andere leerlingen kan werken en kan zitten, want dat voelt gezelliger dan gestructureerd met z'n tweeën naast elkaar. Het voelt alsof je meer vrijheid hebt in de les terwijl je alsnog gewoon op de docent kan letten"

Student E, 0.10: "An attractive classroom really helps with concentration and student cooperation." – Student E, 0.10
"Een aantrekkelijk lokaal helpt echt bij de concentratie en meewerking van leerlingen"

Student F, 0.10: "Nice atmosphere with a homely feel. It's a chill classroom with comfortable chairs. I think it's a beautiful classroom and it makes you more social…" – Student F, 0.10. "
"Leuke sfeer met een goed thuisgevoel. Het is een chill lokaal met comfortabele stoelen. Ik vind het een mooi lokaal en het maakt je socialer…"

Student G, 0.10: "I like the concept of the layout, but in practice it is less convenient because many students get distracted." – Student G, 0.10
"Ik vind het concept van de opzet leuk, maar in de praktijk is het wat minder handig, omdat veel leerlingen afgeleid raken"

Student H, 0.10: "A nice atmosphere – a chill classroom. Comfortable and beautiful." – Student H, 0.10
Leuke sfeer – Chill lokaal - Comfortabel en mooi lokaal

Student I, 0.10: "I like the concept of the layout, but in practice it is less convenient because many students get distracted." – Student I, 0.10
Ik vind het concept van de opzet leuk, maar in de praktijk is het wat minder handig, omdat veel leerlingen afgeleid raken.

Student J, 0,10: "This classroom is too cosy and pleasant to really get down to serious work." – Student J, 0.10
Dit lokaal is te sfeervol en gezellig om serieus aan de slag te gaan.

Student A, 2.01-2.02: *"In the first part, you just sit in a normal classroom. The second room is better, because there you can work much more freely." – Student A, 2.01-2.02*
Dutch original: "In het eerste deel zit je gewoon in een normaal lokaal, De tweede ruimte is beter, want daar werk je veel vrijer"

Student B, 2.01-2.02: *"Spacious classroom, and you can make use of different zones." – Student B, 2.01-2.02.*
Dutch original: "Ruim lokaal en je kan gebruik maken van aparte zones."

Student C, 2.01-2.02*: "We only use the space at the back every now and then, mostly after school or for special projects. During regular lessons, it just stays empty." – Student C, 2.01–2.02*
Dutch original: "We gebruiken de ruimte achterin maar af en toe, meestal na schooltijd of voor speciale projecten. Tijdens normale lessen blijft het gewoon leeg."

Student D, 2.01-2.02: "Sometimes we use the back part for group work or to keep our stuff…" – Student D, 2.01-2.02
Dutch original: "Soms gebruiken we het achterste gedeelte voor groepswerk of om onze spullen neer te zetten…"

Student E, 2.01-2.02: "I like working independently in the space at the back. I find it really relaxing, and it motivates me to actually get things done. It's quieter than working in the other classroom with everyone together." – Student E, 2.01–2.02
Dutch original: "Ik werk graag zelfstandig in de ruimte achterin. Ik vind het heel ontspannen en het motiveert me om echt dingen gedaan te krijgen. Het is rustiger dan werken in het andere lokaal met iedereen samen."

Student F, 2.01-2.02"*"It feels a bit too cosy to really get down to serious work, and the busy appearance makes it harder to focus."* – Student F, 2.01–2.02
Dutch original: *"Het voelt een beetje te gezellig om echt serieus aan de slag te gaan, en het drukke uiterlijk maakt het lastiger om te focussen."* – Student, 2.01–2.02

Student A, 2.04: *"It's sometimes quite warm and doesn't smell very fresh…" –Student A, 2.04*
Dutch original: "Het is af en toe best warm en het ruikt niet zo fris…"

Student B, 2.04: *"It always smells bad, no fresh air. And it's a bit too small for our class." – Student B, 2.04*
Dutch original: "Het ruikt altijd slecht met weinig frisse lucht. Ook is het een beetje te small voor onze klas."

Appendix 4 – INTERVIEW QUESTIONS & CITATIONS

List of interviews

Interview Case:	**Case A – school A**	**Case B – school B**
Date:	14 mei 2025	20 mei 2025
Time:	Ca. 35 minutes	
Location	On location	Extern
Experience within the Case:	8 years of experience at school A	2 years of experience
Role:	Teacher in classroom 2.15 and 2.04	Teacher in classroom 0.10
Interviewer	B. Tokyay	B. Tokyay

Introductie:
Allereerst hartelijk dank dat u de tijd neemt voor dit interview. Mag ik, voordat we beginnen, uw toestemming vragen om dit gesprek op te nemen?
Mijn naam is Beyza Tokyay. Ik ben momenteel laatstejaars student aan de Technische Universiteit Delft, waar ik de master Management in the Built Environment volg. Daarnaast werk ik als projectmanager binnen het domein van onderwijshuisvesting. In deze rol dragen we actief bij aan het optimaliseren van schoolgebouwen en het vertalen van de wensen en eisen van gebruikers naar een passend eindresultaat.
Voor mijn afstudeeronderzoek richt ik mij op de vraag hoe klaslokalen in middelbare scholen optimaal ingericht kunnen worden om de leerprestaties van leerlingen te bevorderen. Hierbij kijk ik onder andere naar de tevredenheid van leerlingen met hun leeromgeving, hun motivatie en hun productiviteit binnen het klaslokaal. Inmiddels zijn er enquêtes afgenomen onder leerlingen en de resultaten daarvan zijn binnen.
Het doel van dit interview is om uw ervaringen met het klaslokaal in kaart te brengen en de bevindingen van de leerlingen te bespreken. Op die manier kunnen we deze resultaten valideren vanuit een ander perspectief, namelijk dat van de docenten. Ik heb een aantal vragen voorbereid om het interview in goede banen te leiden. We beginnen met enkele algemene vragen, gevolgd door vragen over uw eigen ervaringen met de klaslokalen. Tot slot zullen we eindigen met een aantal vragen aan de hand van de resultaten van de leerlingen en ik hoor graag uw visie daarop.

Interview Questions:

1. Kunt u uzelf introduceren en iets vertellen hoelang u al werkt bij het [CASE NAME]?
2. Welk vak geeft u? En geeft u les in lokalen [CASE LOKAAL]?

Ervaring docent:

1. Hoe ervaart u zelf het lokaal? (M.b.t. licht, ruimte, meubilair, etc.)
2. In hoeverre heeft u de mogelijkheid (en ruimte) om de inrichting van het lokaal aan te passen aan uw lesmethodes of de behoeften van de leerlingen?
3. Hoe zou u idealiter het lokaal willen inrichten om het leerproces beter te ondersteunen?
4. Zijn er specifieke ruimtelijke elementen die u mist of juist erg waardeert in het lokaal?

Blik op resultaten leerlingen:

1. Hoe ervaart u zelf de invloed van het klaslokaal op de motivatie, concentratie en prestaties van uw leerlingen?
2. Merkt u verschil in het gedrag of de betrokkenheid van leerlingen afhankelijk van in welk lokaal de les plaatsvindt? Zo ja, waar ligt dat volgens u aan?
3. Wat vindt u van deze opmerkingen [opvallend heden in resultaten per case]?

Afsluitende vraag
Dat waren al mijn vragen. Heeft u zelf nog vragen of opmerkingen die u zou willen toevoegen?
Dan wil ik u bedanken voor uw tijd en medewerking. Ik zal u binnen een aantal dagen het transcript opsturen en indien u wilt, kan ik u wanneer mijn afstudeeronderzoek is afgrond, de resultaten opsturen.

TEACHER QUOTES FROM INTERVIEWS (DUTCH ORIGINAL):

Teacher A, 0.10: *"Yes especially, when you still want to say something as a teacher. Then they are still kind of busy with each other" or "So you could say the classroom looks nice. But it's actually not suitable for didactics, for direct instruction." – Teacher A, 0.10*
Dutch original: "Ja, vooral als je als docent nog iets wilt zeggen. Dan zijn ze nog steeds een beetje met elkaar bezig." of "Je zou kunnen zeggen dat het lokaal er mooi uitziet. Maar het is eigenlijk niet geschikt voor didactiek, voor directe instructie."

Teacher B, 0.10: *"I think this new generation does value aesthetics. So if the classroom also looks nice, they might pay better attention than in a dull white room." – Teacher B, 0.10.*
Dutch original: "Ik denk dat deze nieuwe generatie toch wel haar waarde hecht aan aesthetics. Dus als het lokaal er ook mooi uitziet, dan zullen ze ook misschien beter opletten dan een saai wit lokaal."

Teacher C, 0.10: *"In that classroom, I do miss the feeling of actually being in a classroom. It feels a bit more like you're in some kind of cafeteria." – Teacher C, 0.10*

- *Translated Dutch: "In dat lokaal mis ik toch wel het gevoel dat je in een klaslokaal zit. Het lijkt iets meer alsof je in een soort kantine zit."*

Teacher A, 2.01-2.02: *"From the front, it's harder to see what everyone is doing when they're spread out in different arrangements, so I tend to keep them in a more traditional setup." - Teacher A, 2.01-2.02*
Dutch original: "Vanaf de voorkant is het lastiger om te zien wat iedereen doet wanneer ze verspreid in verschillende opstellingen zitten, dus houd ik ze meestal in een meer traditionele indeling."
Teacher C: *"The classrooms we see here are quite warm in terms of wall color. I think that was done intentionally. Certain elements are really bright yellow." – Teacher C*
Dutch original: "De lokalen die we hier zien zijn best wel warm qua kleur van de muren. Het is wel, denk ik, met opzet zo gedaan. Bepaalde elementen zijn wel knalgeel."

Teacher D: *"For example, when you're in a classroom with a lot of color... you can get overstimulated. That's probably why you often see the somewhat duller designs in classrooms. It helps keep the focus on the lesson." – Teacher D*
Dutch original: "Bijvoorbeeld ook als je in een lokaal zit waar heel veel kleur aanwezig is... dan wordt je overprikkeld. Daarom waarschijnlijk ook de iets saaiere inrichting die je vaak ziet in de klaslokalen. Dan blijft de aandacht toch wel bij de les."

DE IMPACT VAN ONDERWIJSVASTGOED OP LEERPRESTATIES

Uitnodiging voor deelname aan onderzoek

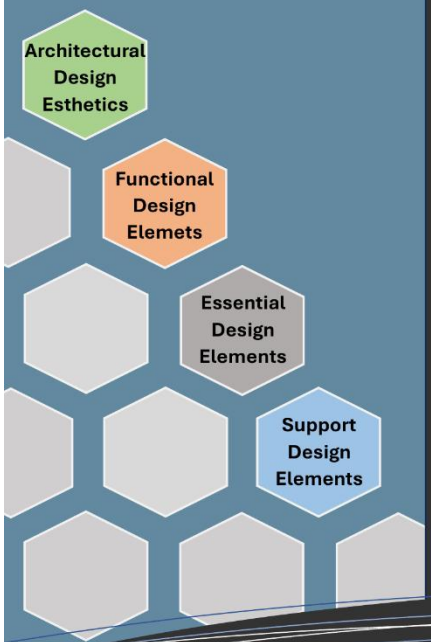
Onderzoeker: Beyza Tokyay, BSc.

Ik ben een laatstejaars masterstudent *Management in the Built Environment* aan de Technische Universiteit Delft en projectmanager Onderwijsdomein bij KWK Huisvestingsregisseurs.

Met een bouwkundig achtergrond en een sterke interesse in de invloed van de gebouwde omgeving op menselijk gedrag, welzijn, en productiviteit.

Met dit onderzoek combineer ik academische inzichten met praktische aanbevelingen voor scholen, beleidsmakers en architecten om leeromgevingen te optimaliseren.

Want als we gebouwen slimmer en effectiever inzetten, kunnen we écht een verschil maken in de toekomst van het onderwijs.



Dit onderzoek richt zich op de invloed van onderwijsvastgoed (het schoolgebouw) op de academische prestaties van middelbare scholieren. We willen beter begrijpen hoe de fysieke leeromgeving bijdraagt aan de leerprestaties van leerlingen middels het meten van hun tevredenheid. Door middel van casestudies waarin te werk zal worden gegaan met enquêtes bij studenten, een focusgroep sessie en een reflecterend interview met directie analyseren we welke vastgoedkenmerken de leerervaring verbeteren.

WAAROM DIT ONDERZOEK?

Schoolgebouwen zijn meer dan functionele ruimtes; ze beïnvloeden het welzijn, de motivatie en de leerprestaties van leerlingen. Dit onderzoek helpt scholen om:

- ✓ Inzicht te krijgen in de relatie tussen vastgoedkenmerken en leerprestaties.
- ✓ Praktische aanbevelingen te ontvangen voor een effectievere leeromgeving.
- ✓ Onderbouwde adviezen voor toekomstig onderwijsvastgoed te formuleren.

WAT VRAGEN WE VAN DEELNEMENDE SCHOLEN?

- ☒ Toegang tot een geselecteerde leeromgeving (bijv. klaslokalen of studieplekken).
- ☒ Deelname van leerlingen (≥16 jaar) aan een korte enquête over hun tevredenheid met de leeromgeving (duur: maximaal 8 minuten)
- ☒ Een kleine groep geïnteresseerde studenten voor een verdiepende discussie over de impact van hun leeromgeving op leerprestaties, in de vorm van een focusgroep.
- ☒ Een reflecterend interview met een schooldirecteur/ -directrice over het huidige schoolgebouw en de invloed ervan op de leerprestaties van de studenten.

SELECTIECRITERIA VOOR DEELNAME

- ☒ HAVO / VWO school met bovenbouwstudenten (≥16 jaar) die willen meedoen.
- ☒ Minimaal 1 jaar operationeel (voor voldoende gebruikservaring).
- ☒ Schoolgebouw niet ouder dan 15 jaar
  - **OF** klaslokaal moet recentelijk (in de afgelopen 5 jaar) zijn gerenoveerd.
- ☒ (Interactieve klaslokalen voor traditioneel onderwijs)

Bent u geïnteresseerd in deelname of wilt u meer informatie? Neem contact op met me middels onderstaande gegevens. Alvast bedankt!

Beyza Tokyay, BSC. Tel.: 06 39 32 44 38 E-Mail: btokyay@tudelft.nl Technische Universiteit Delft | MSc. Management in the Built Environment – Master Thesis

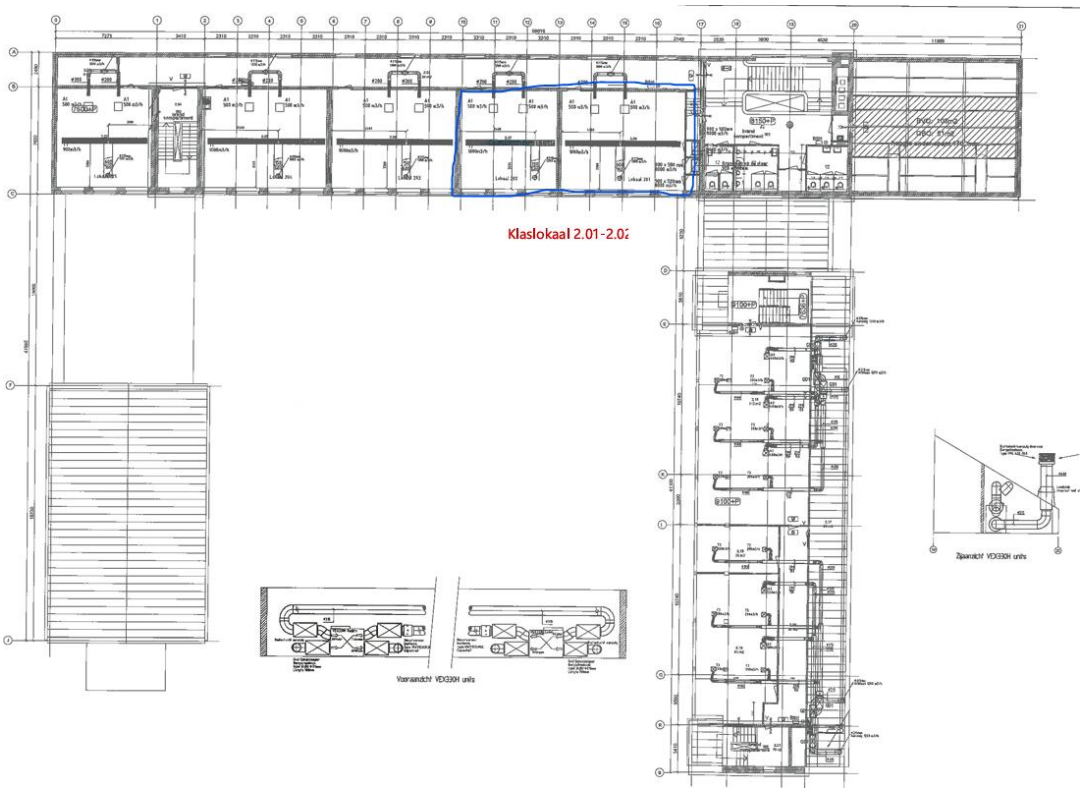
Appendix 6 – FLOORPLAN SCHOOLS

School A – First floor with the three classrooms

- Classroom 2.04, 2.07 and 2.15.

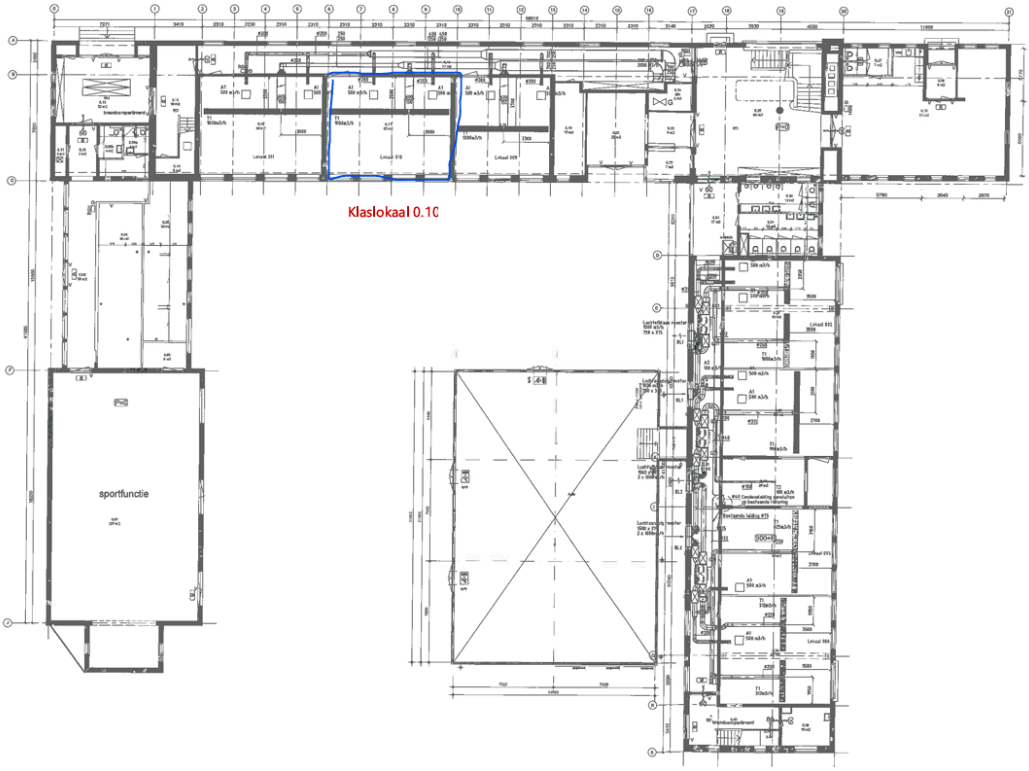
School B – Ground floor and upper-grade classroom.

Ground floor:



- Classroom 2.01-2.02

Second floor:



- Classroom 0.10

Appendix 7 – Data Management Plan

Plan Overview

A Data Management Plan created using DMPonline
Title: The Impact of the classroom environment
Creator: Beyza Tokyay
Affiliation: Delft University of Technology
Template: TU Delft Data Management Plan template (2025)

Project abstract:

Project abstract: This research investigates how the design and use of the classroom environment can enhance students learning experience by analyzing what the impact is of certain design and use elements on their satisfaction, motivation and perceived productivity. Through a mixed-methods approach – combining **interviews, surveys, and focus groups** – the research investigates how specific design features influence student perceptions and their learning experience. The main research question, **"How does the design and use of classroom environments influence the learning experience of secondary school students"**, guides the study, offering practical recommendations for creating educational spaces that foster both student learning experience and academic success.
Research methods & collected data: Interview with schoolteachers, surveys with secondary school students (upper-grade students), focus groups with students.
Interview data and findings out of the focus group will be made anonymous by leaving out personal information and the data collection from the survey will be made anonymous as well.
Study will be conducted at two secondary schools in the Netherlands. Participants range from secondary school students to school principals to gain knowledge about their perception on educational real estate features and characteristics.
Goal of this research: to find a correlation between classroom environment elements and student learning experience by understanding student perceptions on these elements and measuring their satisfaction, motivation, and productivity with the learning environment.
Research sub-questions:
1)Which design and use aspects, identified through literature, contribute to a classroom environment that supports student learning experiences?
2) Which indicators are suitable for measuring the student learning experience in relation to classroom design and use?
3) How do secondary school students experience their current classroom environment and how does it influence their learning experience with focus on satisfaction, motivation and productivity?
4) How can the insights into design and use be translated into concrete recommendations for the future management of classroom environments?

ID: 169797

Start date: 02-09-2024

End date: 28-10-2025

Last modified: 18-08-2025

The Impact of the classroom environment

0. Administrative questions
1. Provide the name of the data management support staff consulted during the preparation of this plan and the date of consultation. Please also mention if you consulted any other support staff.
The DMP has been shared with my thesis supervisor Monique Arkesteijn and Sake Zijlstra via DMPOnline on 03/02/2025. Based on p.13 in the TU Delft Research Data Framework Policy, the responsible researcher for my ethical application is Monique Arkesteijn, since I'm a student. She has been consulted regarding the creation of the DMP, the HREC checklist, and informed of consent materials.
I also received additional support from the Privacy officer of the Privacy Team of the TU Delft, Lieke Font Freide, on 03/03/2025.

2. Is TU Delft the lead institution for this project?

Yes, the only institution involved

I. Data/code description and collection or re-use

3. Provide a general description of the types of data/code you will be working with, including any re-used data/code.

Type of data/code	File format(s)	How will data/code be collected/generated? For re-used data/code: what are the sources and terms of use?	Purpose of processing	Storage location	Who will have access to the data/code?
Personally Identifiable Information (PII) for the interviews: Participants' name, email, mobile number (work), company name, and work address.	.pdf, .xlsx	Contact information for participants taking part in interviews, received from professional network. Informed consent forms are signed digitally and contain participants' name and e-mail.	For administrative purposes: obtaining informed consent and communicating with participants.	Project Data Storage	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra
Informed consent forms	.pdf	Informed consent forms signed digitally	To obtain and document informed consent.	Project Data Storage	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra.
Personally Identifiable Research Data (PIRD): Audio-recordings of Interviews with participant of Schoolboard or school principal to gain their perception and opinion.	.mp3	Interviews are conducted during on-site visits to the secondary schools. Audio-recordings are made on an external device, before being moved to Data Storage. Recordings will be deleted after transcription.	Capturing the opinions of school principals on the impact of the learning environment on their student's performance.	External recording device (temporary storage) + Project Data Storage (primary storage).	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra
Anonymous Transcriptions of interview with school principals.	.txt	Anonymous transcriptions are created manually based on audio-recordings.	Privacy-preserving data on the perception of the learning environment and student performance from the perspective of the school principals.	Project Data Storage	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra
Anonymized data on opinion on the perception of school principals on the learning environment and its impact on student performance.	.csv	Data obtained from coding anonymized transcriptions using ATLAS.TI. TU Delft has a campus license.	Privacy-preserving data on opinions on the perception from school principals on the learning environment and its impact on student performance.	Project Data Storage	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra
Anonymous survey data on student satisfaction and their perception on their learning environment.	.csv, .xlsx. .pdf	Online survey in Microsoft Forms (MS Forms). An anonymous link will be used, and IP-address tracking will be turned off. The survey will be distributed through the school principal only to upper-grade students at the secondary school. Project members do not have access to this mailing list.	Capturing the perceptions and their satisfaction with the learning environment from upper-grade students at the selected secondary schools.	MS Forms (Temporary storage) + Project Data Storage (Primary storage).	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra
Personally Identifiable Information (PII) for the focus group: Participants' name and grade.	.pdf .xlsx.	Contact information for participants taking part in the focus group, received from school principals. Informed consent forms are signed digitally and contain participants' name and grade. The students will be invited by the school principal	For administrative purposes: obtaining informed consent and communicating with participants.	Project Data Storage	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra

		himself so no further personal data will be exchanged.			
Informed consent	.pdf	Informed consent forms signed digitally.	To obtain and document informed consent.	Project Data Storage	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra
Personally Identifiable Research Data (PIRD): Audio-recordings of focus group with students.	.mp3	focus groups are conducted at the school. Audio-recordings are made on an external device, before being moved to Data Storage. Recordings will be deleted after transcription.	Capturing the opinions of students on the outcomes of the anonymous survey.	External recording device (temporary storage) + Project Data Storage (primary storage).	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra
Anonymous Transcriptions of focus group with students.	.txt,	Anonymous transcriptions are created manually based on audio-recordings.	Privacy-preserving data on the perception of the learning environment and student performance from the perspective of the students.	Project Data Storage	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra
Anonymized data on opinion on the survey results through students.	.csv	Data obtained from coding anonymized transcriptions using ATLAS.TI. TU Delft has a campus license.	Privacy-preserving data on opinions on the survey results in the focus group.	Project Data Storage	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra
Report/thesis	.pdf	Serves as record of the process as well as documentation	Long-term documentation	Project Data Storage	Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra

II. Storage and backup during the research process

4. How much data/code storage will you require during the project lifetime?
250 GB – 5 TB

5. Where will the data/code be stored and backed up during the project lifetime? (Select all that apply.)
Project Data Storage (U:) drive at TU Delft
Another storage system – please explain below, including provided security measures
1- Project Data Storage (U:) drive at TU Delft: Primary research data storage. Only TU Delft team members (Beyza Tokyay, Monique Arkesteijn, and Sake Zijlstra) have access. Survey, interview data and focus group data will be stored in separate folders, and within the interview & focus group folder, there are separate folders for audio-recordings and anonymous transcriptions. Informed consent forms and contact information are encrypted separately from research data to minimize risk of re-identification.
Another storage system:

2- External recording device: Used as a temporary storage location for recorded on-site interviews. Interviews will be deleted from device as soon as they are moved to OneDrive.

3- Microsoft Forms (MS Forms): server of online survey platform. Temporary storage for anonymous survey responses. I will be using an anonymous link and IP-address tracking will be turned off.

III. Data/code documentation

6. What documentation will accompany data/code? (Select all that apply.)
Data – Methodology of data collection
The dataset will not be shared in a data repository, but the methodology of data collection will be explained in the MSc thesis, which is made publicly available in the TU Delft Repository.

IV. Legal and ethical requirements, code of conduct

7. Does your research involve human subjects or third-party datasets collected from human participants? If you are working with a human subject(s), you will need to obtain the HREC approval for your research project.
Yes – please provide details in the additional information box below
I intend to apply for ethical approval from the Human Research Ethics Committee (HREC) but have not yet done so. I am, as a student, the corresponding researcher and my supervisor, Monique Arkesteijn, is the responsible researcher for the HREC application.

HREC approval ID: 5429.

8. Will you work with personal data? (This is information about an identified or identifiable natural person, either for research or project administration purposes.)
Yes
The research data collected in the project will be anonymized, but processing of personal data is required for conducting the research project.
The data from the survey will be received anonymized because an anonymous link will be used and IP-address tracking will be turned off.

9. Will you work with any other types of confidential or classified data or code as listed below? (Select all that apply and provide additional details below.)
If you are not sure which option to select, ask your Faculty Data Steward **for advice.**
No, I will not work with any other types of confidential or classified data/code

10. How will ownership of the data and intellectual property rights to the data be managed? For projects involving commercially-sensitive research or research involving third parties, seek advice of your Faculty Contract Manager **when answering this question.**
The student conducts the research independently, and is the owner of the interview, focus group, and survey data. The anonymized interview, focus group, and survey data underlying the graduation report will be included in the body and appendix of the MSc thesis, which will be uploaded with public access to the TU Delft Repository.

11. Which personal data or data from human participants do you work with? (Select all that apply.)
Free text fields (for instance, in questionnaires) in which participants could unintentionally share personal data
Proof of consent (such as signed consent materials which contain name and signature)

Audio recordings

Telephone number, email addresses and/or other addresses as contact details for administrative purposes

Names as contact details for administrative purposes

Personally Identifiable Research Data (PIRD): Audio-recordings from school principals and students: interviews and focus groups only, measuring their (Professional) opinion and perception on the learning environment and its possible effects on student performance. We won't gather any (statistical) data and focus only on opinions and perceptions.

Personally Identifiable Research Data (PIRD): Perceptions on the learning environment and their performances by students: Survey only.

Data for administrative purposes - Personally Identifiable Information (PII):

Names, contact details and school name - for interview

Class and school name: information about which grade and school they are (we will conduct this survey at 2 schools) - for surveys and focus group

The online survey data is collected anonymously via MS Forms (using anonymous links and without collecting IP-addresses). Multiple-choice, or yes/no questions are used in the survey with free text fields to further elaborate on the answer or highlight a different perspective. Answers that will contain identifiable personal data in the free text fields will be deleted.

Participant data for interviewees and focus groups will be anonymized when recordings are transcribed.

12. Please list the categories of data subjects and their geographical location.
Interview participants are the school principals, who are involved in the learning environment of students, in urban areas in the Netherlands.

Focus group participants are the students (16y-18+ years) of the school, who are involved in the learning environment, in urban areas like in the Netherlands.

Survey participants are the students (16y-18+ years) of the school, who are involved in the learning environment, in urban areas like in the Netherlands.

13. Will you be receiving personal data from or transferring personal data to third parties (groups of individuals or organizations)?
No, there won't be a third party to receive or transfer personal data to.

16. What are the legal grounds for personal data processing?
Informed consent
The HREC informed consent guide and template will be used to create the informed consent forms for the interviewees and participants of the focus group (template 1 in the HREC guide). For the anonymous surveys, an opening statement (template 2 in the HREC guide) will be used in place of the explicit informed Consent Form.

17. Please describe the informed consent procedure you will follow below.
Interviews & Focus groups: the researcher will inform the potential participants about the goals and procedures of the research project. The researcher will also inform them about the personal data that is being processed and for what purpose. A digital copy of the information will be emailed to participants before the interview, and all participants will be asked for their consent to take part in the study and for data processing by signing a digital informed consent form before the start of the interview. I strive to work with upper-grade students from 16-18 years old. From students under the age of 16 years a consent form needs to be signed by their guardians. So, we will try to only invite students from 16 years and older.
Survey: For the anonymous surveys, an Opening Statement will be used at the start of the survey to inform participants about the goals and procedures of the research project, as well as the type of information that is requested in the survey. Participants' agreement with the terms and conditions of the research are signified by clicking through to the survey.

18. Where will you store the physical/digital signed consent forms or other types of proof of consent (such as recording of verbal consent)?
Digital informed consent forms (digital copy of signed document) and contact information are stored in the Project Data Storage and encrypted separately from research data to minimize risk of re-identification.

19. Does the processing of personal data result in a high risk to the data subjects? (Select all that apply.) If the processing of the personal data results in a high risk to the data subjects, it is required to perform a Data Protection Impact Assessment (DPIA). **In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data in your research project.**
Data concerning vulnerable data subjects

Sensitive personal data

Evaluation or scoring of people or personal performance

My research involves secondary school students, who are considered a vulnerable group due to their age. While the survey data will be collected anonymously, personal data will be processed for the focus groups and interviews: For the focus groups this includes participant's names and their grade level and for the interviews with principals their name, email, mobile number (work), company name, and work address, which are collected for administrative purposes and to obtain informed consent **(PII)**. Additionally, the audio recordings of focus groups are considered personal data **(PIRD)**, as participants may be identifiable based on their voice and statements.

However, according to the DPIA checklist, this data processing does not constitute high-risk processing for personal data, and therefore, a DPIA is not required. This was confirmed by the Privacy team, Lieke Font Freide, on 03/03/2025 via email:

"My understanding from the DMP and your explanation is that the survey itself does not collect any direct identifiable information and that the link to the survey is anonymous (IP address is not collected). Therefore, the survey results are not considered personal data and not in scope of the GDPR. Hence, you do not need a legal basis such as consent and a DPIA is not necessary. If the survey is not anonymous and there is some link to the participant, then the GDPR is applicable, and consent is necessary.

With regard to the focus groups, a DPIA is not necessary, you explained that you will not collect data of participants younger than 16, according to the GDPR people above the age of 16 can give valid consent themselves and there is no need of consent of their legal guardian. Considering they are students, they may be considered vulnerable, but since there is no dependency between you as the researcher and the students, there is no disbalance between the data controller (researcher) and data subjects (participants) and they would feel free to provide consent. Additionally, the focus group is small, so there is no large-scale processing, and you are not interested in any special category of data under art. 9 of the GDPR. Hence there are no triggers to perform a DPIA and therefore it is not required. This also counts when you are processing data of children younger than 16. There is still no disbalance between controller and data subject. But, between the ages of 12-16, consent is required from both the participant as well as their legal guardian according to the law."

To ensure the privacy and protection of participants, the following safeguards will be implemented by the researcher:

Anonymization: all data will be anonymized as soon as possible. And audio recordings will be deleted Focus groups and interview transcripts will be anonymized. The survey link and the invitation for the focus groups with students will be sent by the school principal. The e-mailadresses of the students won't be obtained to limit the amount of personal data.

Limited access: only the researcher and the TU Delft supervisors will have access to personal data, which will be securely encrypted and stored in the Project Data Storage.

Informed consent: All participants will be informed about the processing of personal data and will provide consent via a digitally signed form. I strive to work with upper-grade students from 16-18 years old. From students under the age of 16 years a consent form needs to be signed by their guardians.

No performance measurement: the study does not track individual academic performance in a statistical way. It will only focus on their opinions and perception of student performance in general.

With these measures in place, the risk to participants is minimized while ensuring compliance with ethical and data protection standards.

20. Did the Privacy team advise you to perform a DPIA?
No – please provide details in the additional information box below
I consulted the privacy officer, Lieke Font Freide, on 18-02-2025 via e-mail regarding data processing in this study. The privacy officer confirmed on 03-03-2025 that a DPIA is not required for this research, as the processing does not involve high-risk personal data.
Based on advice of privacy team:

It's important to clarify that the survey data is fully anonymous and does not contain any personally identifiable information (PII). Since no personal data is collected through the survey (as an anonymous link is used, and IP tracking is disabled), the GDPR does not apply to this dataset.

However, personal data is processed in the context of interviews and focus groups. For the focus group participant's name, e-mail addresses, and grade levels are asked for administrative purposes and to obtain an informed consent (PII). For the interview name, email, mobile number (work), company name, and work address, which are collected for administrative purposes and to obtain informed consent (PII).

Additionally, audio recordings of the focus groups are considered personal data, as participants may be identifiable by their voices (PIRD). To mitigate privacy risks, all recordings will be transcribed, and the transcriptions will be fully anonymized.

Informed consent will be obtained from all interviews and focus groups (Students under the age of 16 won't attend this research as we need their parents/guardians informed consent as well) before participation. Personal data will be stored securely and encrypted in Project Data Storage, with access limited to the researcher and supervisors. All personal data will be deleted no later than one month after the completion of the research.

<u>The mail is sent by the privacy team:</u>

"My understanding from the DMP and your explanation is that the survey itself does not collect any direct identifiable information and that the link to the survey is anonymous (IP address is not collected). Therefore, the survey results are not considered personal data and not in scope of the GDPR. Hence, you do not need a legal basis such as consent and a DPIA is not necessary. If the survey is not anonymous and there is some link to the participant, then the GDPR is applicable, and consent is necessary.

With regard to the focus groups, a DPIA is not necessary, you explained that you will not collect data of participants younger than 16, according to the GDPR people above the age of 16 can give consent themselves and there is no need of consent of their legal guardian. Considering they are students, they may be considered vulnerable, but since there is no dependency between you as the researcher and the students, there is no disbalance between the data controller (researcher) and data subjects (participants) and they would feel free to provide consent. Additionally, the focus group is small, so there is no large-scale processing, and you are not interested in any special category of data under art. 9 of the GDPR. Hence there are no triggers to perform a DPIA and therefore it is not required. This also counts when you are processing data of children younger than 16. There is still no disbalance between controller and data subject. But, between the ages of 12-16, consent is required from both the participant as well as their legal guardian according to the law."

23. What will happen with the personal data used in the research after the end of the research project?
Anonymized or aggregated data will be shared with others
Anonymized research data consists of anonymized interview transcripts, focus group transcripts, anonymized coded datasets, anonymous survey data. These data will be used in the body of the thesis and included the appendix but will not be shared in a data repository.
24. For how long will personal research data (including pseudonymized data) be stored?
Personal data will be deleted at the end of the research project
Audio-recordings of interviews are destroyed after completion of anonymized interview and focus group transcriptions. All other personal research data will be destroyed at the latest 1 month after the end of the project.
25. How will your study participants be asked for their consent for data sharing?
In the informed consent form: participants are informed that their personal data will be anonymized and that the anonymized dataset is shared publicly
All participants will be asked for their consent for data to be shared anonymously in the body of the MSc thesis, which is made publicly accessible in the TU Delft Repository. Participants who do not consent to their data being included publicly in the thesis will not be included in the research project.

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 23, will any other data be publicly shared? Please provide a list of data/code you are going to share under 'Additional Information'.
I do not work with any data other than personal data
29. How will you share research data/code, including those mentioned in question 23?
I am a Bachelor's/master's student at TU Delft, and I will share the data/code in the body and/or appendices of my thesis/report in the Education Repository
Anonymized data collected during the project will be included in the body and appendix of the MSc thesis, made available in the TU Delft Repository.
The dataset is not shared in a data repository.
31. When will the data/code be shared?
As soon as corresponding results (papers, theses, reports) are published

VI. Data management responsibilities and resources

33. If you leave TU Delft (or are unavailable), who is going to be responsible for the data/code resulting from this project?
Thesis supervisor, Monique Arkesteijn of the department Architecture and the Built Environment, Real Estate Management:

34. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?
Research data are only shared within the MSc thesis: no additional resources are required. Only the final results like graphs and figures related to the data will be included in the appendix of the thesis and uploaded to the TU Delft Repository.

Appendix 8 – HREC Form

I. Applicant Information

PROJECT TITLE:	**The impact of the Classroom Environment**
Research period: *Over what period of time will this specific part of the research take place*	Start date: 02/09/2024 End date: 28/10/2025
Faculty:	**Architecture and the Built Environment**
Department:	Management in the Built Environment
Type of the research project: *(Bachelor's, Master's, DreamTeam, PhD, PostDoc, Senior Researcher, Organisational etc.)*	Master's thesis
Funder of research: *(EU, NWO, TUD, other – in which case please elaborate)*	
Name of Corresponding Researcher: *(If different from the Responsible Researcher)*	Student: Beyza Tokyay, BSc.
E-mail Corresponding Researcher: *(If different from the Responsible Researcher)*	
Position of Corresponding Researcher: *(Masters, DreamTeam, PhD, PostDoc, Assistant/ Associate/ Full Professor)*	Masters
Name of Responsible Researcher: ***Note:** all student work must have a named Responsible Researcher to approve, sign, and submit this application*	Dr. Monique Arkesteijn
E-mail of Responsible Researcher: *Please ensure that an institutional email address (**no Gmail, Yahoo, etc.**) is used for all project documentation/ communications including Informed Consent materials*	
Position of Responsible Researcher : *(PhD, PostDoc, Associate/ Assistant/ Full Professor)*	Full professor

II. Research Overview

***NOTE:** You can find more guidance on completing this checklist here*

a) Please summarise your research very briefly (100-200 words)

What are you looking into, who is involved, how many participants there will be, how they will be recruited and what are they expected to do?

Add your text here – (please avoid jargon and abbreviations)
This research investigates how the design and use of classroom environments can enhance student learning experience by increasing student satisfaction, motivation, and perceived productivity in secondary schools.. I will be using interviews with schoolteachers and surveys with students. Interviews with schoolteachers (2) will be recruited through the school and the surveys will be conducted with students at two different schools (2/3 classes of each school, approximately 50 students each school). The survey link will be sent through an anonymous link shared by the school principal to the students and the students for the focus group will be invited by the school principal. The participants are expected to share the experience and perceptions on their learning environment and possible impacts on their satisfaction, motivation, and perceived productivity. It's only to gain their opinion and no data about their performance will be asked. Participants will provide informed consent before participating in interviews or focus groups. Data will be anonymised and securely stored in TU Delft's Project Data Storage (U: drive).

b) **If your application is an additional project** related to an existing approved HREC submission, please provide a brief explanation including the existing relevant HREC submission number/s.

Add your text here – (please avoid jargon and abbreviations)
This application is for a new research project and is not related to any previously approved HREC submissions.

c) **If your application is a simple extension of, or amendment to,** an existing approved HREC submission, you can simply submit an HREC Amendment Form as a submission through Lab Servant.

III. Risk Assessment and Mitigation Plan

NOTE: *You can find more guidance on completing this checklist here*

Please complete the following table in full for all points to which your answer is "yes." Bear in mind that the vast majority of projects involving human participants as Research Subjects also involve the collection of **Personally Identifiable Information (PII)** and/or **Personally Identifiable Research Data (PIRD)** which may pose potential risks to participants as detailed in Section G: Data Processing and Privacy below.

To ensure alignment between your risk assessment, data management and what you agree with your Research Subjects you can use the last two columns in the table below to refer to specific points in your Data Management Plan (DMP) and Informed Consent Form (ICF) – **but this is not compulsory**.

It's worth noting that **you're much more likely to need to resubmit your application if you neglect to identify potential risks**, than if you identify a potential risk and demonstrate how you will mitigate it. If necessary, the HREC will always work with you and colleagues in the Privacy Team and Data Management Services to see how, if at all possible, your research can be conducted.

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		***Please provide the relevant reference #***	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** ***Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!***	**MITIGATION PLAN – what mitigating steps will you take?** ***Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.***	**DMP**	**ICF**
A: Partners and collaboration						
1. Will the research be carried out in collaboration with additional organizational partners such as: • One or more collaborating research and/or commercial organizations • Either research, or a work experience internship provider[1] [1] *If yes, please include the graduation agreement in this application*		**NO**	**No external organization partners are involved.**	Not applicable.		
2. Is this research dependent on a Data Transfer or Processing Agreement with a collaborating partner or third-party supplier?		**NO**	**No third-party data transfer is required.**	Not applicable		

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
If yes please provide a copy of the signed DTA/DPA						
3. Has this research been approved by another (external) research ethics committee (e.g.: HREC and/or MREC/METC)? *If yes, please provide a copy of the approval (if possible) and summarise any key points in your Risk Management section below*		**NO**	**No external ethics committee approval is required**	Not applicable		
B: Location						
4. Will the research take place in a country or countries, other than the Netherlands, within the EU?		**NO**	**The study will only be conducted in the Netherlands**	Not applicable		
5. Will the research take place in a country or countries outside the EU?		**NO**	**The research is limited to the Netherlands**	Not applicable		
6. Will the research take place in a place/region or of higher risk – including known dangerous locations (in any country) or locations with non-democratic regimes?		**NO**	**No high-risk locations are involved**	Not applicable.		
C: Participants						
7. Will the study involve participants who **may** be vulnerable and possibly (legally) unable to give informed consent? (e.g., children below the legal age for giving consent, people with learning difficulties, people living in care or nursing homes,).	**YES**		**Secondary school students (ages 16-18) are considered vulnerable due to age.**	We will strive to only work with students above the age of 16 years. Participants will receive age-appropriate explanations. Students under the age of 16 need Parental/guardian consent before attending the research. The researcher will not have direct access to student contact details. The invitations will be sent by the		

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
				school principal himself. Participation is voluntary and anonymized.		
8. Will the study involve participants who **may** be vulnerable under specific circumstances and in specific contexts, such as victims and witnesses of violence, including domestic violence; sex workers; members of minority groups, refugees, irregular migrants or dissidents?		**NO**	**No participants belong to highly vulnerable groups.**	Not applicable.		
9. Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children, own students or employees of either TU Delft and/or a collaborating partner organisation)? *It is essential that you safeguard against possible adverse consequences of this situation (such as allowing a student's failure to participate to your satisfaction to affect your evaluation of their coursework).*		**NO**	**The researcher does not have a supervisory or evaluative role over participants.**	Not applicable.		
10. Is there a high possibility of re-identification for your participants? (e.g., do they have a very specialist job of which there are only a small number in a given country, are they members of a small community, or employees from a partner company collaborating in the research? Or are they one of only a handful of (expert) participants in the study?	**YES**		**Audio recordings of focus groups contain identifiable voices. Also, names of the school will be named in the thesis which can give a possibility of re-identification to participants.**	All audio recordings will be transcribed and fully anonymized, removing personally identifiable information (PII), such as names, ages, genders and other personal information. Audio files (PIRD) will be securely stored and deleted immediately after transcription. No PII or PIRD of students or the school principal will be included in the results. Participants will be		

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
				informed about these measures to ensure transparency and data protection.		
D: Recruiting Participants						
11. Will your participants be recruited through your own, professional, channels such as conference attendance lists, or through specific network/s such as self-help groups	**YES**		**School teachers and students will be contacted through the school principals.**	Through my professional network I got in contact with housing manager within school boards. School principals are asked for voluntary participation by the housing managers. Recruitment of students and teachers will be done in collaboration with school principals to ensure voluntary participation of students.		
12. Will the participants be recruited or assessed in the longer term by a (legal or customary) gatekeeper? (e.g., an adult professional working with children; a community leader or family member who has this customary role – within or outside the EU; the data producer of a long-term cohort study)		**NO**	**The school principal will distribute the survey once and invite the students once to the focus group. This won't be longer because we will only ask them once.**	Not applicable, participants won't be recruited or assessed in the longer term.		
13. Will you be recruiting your participants through a crowd-sourcing service and/or involve a third-party data-gathering service, such as a survey platform?		**NO**	**The survey will be conducted via Microsoft Forms (MS Forms) with no external recruitment service.**	Microsoft Forms ensures anonymity with no IP-address tracking.		
14. Will you be offering any financial, or other, remuneration to participants, and might this induce or bias participation?		**NO**	**No incentives will be provided. Participation is entirely voluntary.**	Not applicable.		
E: Subject Matter *Research related to medical questions/health may require special attention. See also the website of the CCMO before contacting the HREC.*						

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
15. Will your research involve any of the following: • Medical research and/or clinical trials • Invasive sampling and/or medical imaging • Medical and *In Vitro Diagnostic Medical* Devices Research		**NO**	**The research does not involve medical studies**	Not applicable.		
16. Will drugs, placebos, or other substances (e.g., drinks, foods, food or drink constituents, dietary supplements) be administered to the study participants? *If yes see here to determine whether medical ethical approval is required*		**NO**	**No substances will be administered**	Not applicable.		
17. Will blood or tissue samples be obtained from participants? *If yes see here to determine whether medical ethical approval is required*		**NO**	**No biological samples will be collected**	Not applicable.		
18. Does the study risk causing psychological stress or anxiety beyond that normally encountered by the participants in their life outside research?		**NO**	**The study focuses on opinions and perceptions, not personal distressing topics.**	Not applicable.		
19. Will the study involve discussion of personal sensitive data which could put participants at increased legal, financial, reputational, security or other risk? (e.g., financial data, location data, data relating to children or other vulnerable groups) *Definitions of sensitive personal data, and special cases are provided on the TUD Privacy Team website.*	**YES**		**No sensitive personal data will be collected. I will be working with students between 16-18 years old. Only Personal Identifiable Information (PII) will be collected for administrative purposes and personally identifiable research data (PIRD) in the form of audio recordings due to interviews and focus groups.**	Discussed with the Privacy Team TUD, their advice: "the survey itself does not collect any direct identifiable information and that the link to the survey is anonymous (IP address is not collected). Therefore, the survey results are not considered personal data and not in scope of the GDPR. Hence, you do not need a legal basis such as consent and a DPIA is not		

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** ***Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!***	**MITIGATION PLAN – what mitigating steps will you take?** ***Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.***	**DMP**	**ICF**
				necessary. If the survey is not anonymous and there is some link to the participant, then the GDPR is applicable, and consent is necessary. With regard to the focus groups a DPIA is not necessary, you explained that you will not collect data of participants younger than 16, according the GDPR people above the age of 16 can give valid consent themselves and there is no need of consent of their legal guardian. Considering they are students, they may be considered vulnerable, but since there is not dependency between you as the researcher and the students, there is no disbalance between de data controller (researcher) and data subjects (participants) and they would feel free to provide consent. Additionally, the focus group is small, so there is no large-scale processing, and you are not interested in any special category of data under art. 9 of the GDPR. Hence there are no triggers to perform a DPIA and therefore it is not required. This also counts when you are processing data of children younger than 16. There is still no disbalance between controller		

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** ***Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!***	**MITIGATION PLAN – what mitigating steps will you take?** ***Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.***	**DMP**	**ICF**
				and data subject. But, between the age of 12-16, consent is required from both the participant as well as their legal guardian according to the law." So, I will strive to work with students from the age of 16 and above (upper-grade students from the schools). The survey link and the invitation for the focus groups with students will be send by the school principal to prevent further exchange of personal data, such as email addresses from the students. The study does not track individual academic performance in a statistical way. It will only focus on their opinions and perceptions of student performance in general. We don't measure their performances.		
20. Will the study involve disclosing commercially or professionally sensitive, or confidential information? (e.g., relating to decision-making processes or business strategies which might, for example, be of interest to competitors)		**NO**	**No commercially sensitive data is involved**	Not applicable.		

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
21. Has your study been identified by the TU Delft Privacy Team as requiring a Data Processing Impact Assessment (DPIA)? *If yes, please attach the advice/ approval from the Privacy Team to this application*		**NO**	**The privacy team, Lieke Font Freide, confirmed a DPIA is not required on 03/03/2025.**	Not applicable.		
22. Does your research investigate causes or areas of conflict? *If yes, please confirm that your fieldwork has been discussed with the appropriate safety/security advisors and approved by your Department/Faculty.*		**NO**	**The study does not focus on conflict-related topics**	Not applicable.		
23. Does your research involve observing illegal activities or data processed or provided by authorities responsible for preventing, investigating, detecting or prosecuting criminal offences *If so, please confirm that your work has been discussed with the appropriate legal advisors and approved by your Department/Faculty.*		**NO**	**No illegal activities will be observed**	Not applicable.		
F: Research Methods						
24. Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g., covert observation of people in non-public places).		**NO**	**All participants will provide informed consent.**	Not applicable.		
25. Will the study involve actively deceiving the participants? (For example, will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study).		**NO**	**No deception is involved in the study**	Not applicable.		

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
26. Is pain or more than mild discomfort likely to result from the study? And/or could your research activity cause an accident involving (non-) participants?		**NO**	**No physical or emotional distress is anticipated**	Not applicable.		
27. Will the experiment involve the use of devices that are not 'CE' certified? *Only, if 'yes': continue with the following questions:*		**NO**	**No unapproved devices will be used**	Not applicable.		
• Was the device built in-house?		-				
• Was it inspected by a safety expert at TU Delft? *If yes, please provide a signed device report*		-				
• If it was not built in-house and not CE-certified, was it inspected by some other, qualified authority in safety and approved? *If yes, please provide records of the inspection*		-				
28. Will your research involve face-to-face encounters with your participants and if so how will you assess and address Covid considerations?	**YES**		**Interviews and focus groups will be conducted in person.**	**Session will take place in a familiar, controlled environment with ethical safeguards.**		
29. Will your research involve **either:** a) "big data", combined datasets, new data-gathering or new data-merging techniques which might lead to re-identification of your participants **and/or** b) artificial intelligence or algorithm training where, for example biased datasets could lead to biased outcomes?		**NO**	**The study does not involve big data analysis or AI**	Not applicable.		
G: Data Processing and Privacy						

			If YES, please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarize what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
30. Will the research involve collecting, processing and/or storing any directly identifiable PII (Personally Identifiable Information) including name or email address that will be used for administrative purposes only? (Eg: obtaining Informed Consent or disbursing remuneration)	**YES**		Following data will be collected for administrative purposes (PII): **Interviews:** name, email, mobile number (work), company name, and work address. **Focus groups:** name and class levels.	Data will be encrypted and stored securely in TU Delft's Project Data Storage (U: drive) with restricted access.		
31. Will the research involve collecting, processing and/or storing any directly or indirectly identifiable PIRD (Personally Identifiable Research Data) including videos, pictures, IP address, gender, age etc and **what other Personal Research Data** (including personal or professional views) will you be collecting?	**YES**		Audio-recordings of interviews and focus groups that contain personal and professional views.	Audio will be transcribed, anonymized, and deleted after transcription.		
32. Will this research involve collecting data from the internet, social media and/or publicly available datasets which have been originally contributed by human participants		**NO**	No external datasets or social media data will be collected.	Not applicable.		
33. Will your research findings be published in one or more forms in the public domain, as e.g., master's thesis, journal publication, conference presentation or wider public dissemination?	**YES**		Anonymised data and final results will be included in the MSc Thesis.	No personal data will be published. Only anonymised, aggregated results will be made publicly accessible.		
34. Will your research data be archived for re-use and/or teaching in an open, private or semi-open archive?		**NO**	Personal data will not be archived for future research.	All personal data will be deleted within one month after project completion.		

H: More on Informed Consent and Data Management

NOTE: *You can find guidance and templates for preparing your Informed Consent materials) here*

Your research involves human participants as Research Subjects if you are recruiting them or actively involving or influencing, manipulating or directing them in any way in your research activities. This means you must seek informed consent and agree/ implement appropriate safeguards regardless of whether you are collecting any PIRD.

Where you are also collecting PIRD, and using Informed Consent as the legal basis for your research, you need to also make sure that your IC materials are clear on any related risks and the mitigating measures you will take – including through responsible data management.

Got a comment on this checklist or the HREC process? You can leave your comments here

IV. Signature/s

Please note that by signing this checklist list as the sole, or Responsible, researcher you are providing approval of the completeness and quality of the submission, as well as confirming alignment between GDPR, Data Management and Informed Consent requirements.

Name of Corresponding Researcher (if different from the Responsible Researcher) (print)
Beyza Tokyay, BSc.

Signature of Corresponding Researcher:

Date: 06/03/2025

Name of Responsible Researcher (print)
Dr. Monique Arkesteijn

Signature (or upload consent by mail) Responsible Researcher **– Digital consent mail**:

Beste Beyza,

Bij deze mijn digitale toestemming om de HREC in te dienen.

Monique Arkesteijn

Date: 20/03/2025

V. Completing your HREC application

Please use the following list to check that you have provided all relevant documentation

Required:

- **Always:** This completed HREC checklist
- **Always:** A data management plan (reviewed, where necessary, by a data-steward)
- **Usually:** A complete Informed Consent form (including Participant Information) and/or Opening Statement (for online consent)

Appendix 9 - Approval HREC

Date 15-Apr-2025
Correspondence hrec@tudelft.nl

Human Research Ethics
Committee TU Delft
(http://hrec.tudelft.nl)

Visiting address
Jaffalaan 5 (building 31)
2628 BX Delft

Postal address
P.O. Box 5015 2600 GA Delft
The Netherlands

Ethics Approval Application: The Impact of Educational Real Estate on Enhancing Academic Performance
Applicant: Tokyay, Beyza

Dear Beyza Tokyay,

It is a pleasure to inform you that your application mentioned above has been approved.

Thank you very much for your submission to the HREC. Your submission has been approved.
In addition to any specific conditions or notes, the HREC provides the following standard advice to all applicants:

- In light of recent tax changes, we advise you to confirm any proposed remuneration of research subjects with your faculty contract manager before proceeding.
- Please make sure when you carry out your research that you confirm contemporary COVID protocols with your faculty HSE advisor and that ongoing COVID risks and precautions are flagged in the informed consent - with particular attention to this where there are physically vulnerable (e.g., elderly or with underlying conditions) participants involved.
- Our default advice is not to publish transcripts or transcript summaries but to retain these privately for specific purposes/checking; and if they are to be made public, then only if fully anonymised and the transcript/summary itself approved by participants for a specific purpose.
- Where there are collaborating (including funding) partners, appropriate formal agreements, including clarity on responsibilities, including data ownership, responsibilities and access, should be in place, and relevant aspects of such agreements (such as access to raw or other data) are clear in the Informed Consent.

Good luck with your research!

Sincerely,

Dr. C. Shelley-Egan
Chair HREC
Faculty of Technology, Policy and Management

Appendix 10 – Consent forms

I) In-depth Interview - Consent Form

- Consent form: Opening Statement + Consent points.

Dear participant,

You are invited to participate in a research study titled *The Impact of Educational Real Estate on Enhancing Academic Performance*. This study is being conducted by Beyza Tokyay as part of a master's thesis within the Department of Management in the Built Environment at TU Delft.

The purpose of this research is to gain insights into how educational real estate and the physical learning environment influence the student learning experience of secondary school's students. By understanding these dynamics, the study aims to provide practical recommendations for improving the design and use of educational facilities to better support student learning outcomes.

Your participation involves a 30–35-minute interview where you will be asked questions about the role of the learning environment in influencing students' experiences and academic performance. Your responses will contribute to academic research and may be included in publications related to this study.

During the research, personal data will be collected and handled with strict confidentiality. The interview will be audio-recorded for transcription purposes, after which the recordings will be converted into anonymised text and securely stored on TU Delft's Project Storage. The audio recordings will be deleted immediately after transcription. Your identity will remain confidential, and no personally identifiable information will appear in any published material.

Your participation in this study is entirely voluntary. You may decline to answer any question or withdraw from the study at any time, for any reason. If you wish to retract any of your answers or your participation in this research, you can do so within 14 days.

If you have any questions or need further information, please do not hesitate to contact me using the details provided below.

Thank you for considering participating in this research. Your time and insights are greatly appreciated.

Sincerely,

Beyza Tokyay
Delft University of Technology | TU Delft

P.S. See consent points next page.

PLEASE TICK THE APPROPRIATE BOXES	YES	NO
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICIPANT TASKS & VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated 20-03-2025, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction		
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions, and I can withdraw from the study at any time, without having to give a reason.		
3. I understand that taking part in this study involves: an audio recording of the interview and written notes will be taken by the interviewer. The audio recording will be transcribed and only the anonymized transcription will be used in the researcher.		
4. I understand that the study will end after the research has been published.		
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
6. I understand that taking part in the study can involve the following risks: mental discomfort in case of sensitive subjects (student performance). I understand that these will be mitigated by having the ability to stop the interview at any point.		
7. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) (for example, name, age, gender and position) with the potential risk of me identify being revealed.		
8. I understand that the following steps will be taken to minimise the threat of a data breach and protect my identity in the event of such a breach: anonymisation of transcript, limited access to data, secure data storage.		
9. I understand that personal information collected about me that can identify me, such as my name, age, gender, will not be shared beyond the study team.		
10. I understand that the (identifiable) personal data I provide will be destroyed 1 month after the research has finished.		
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
11. I understand that after the research study the de-identified information I provide will be used for publication		
12. I agree that my responses, views or other input can be quoted anonymously in research outputs.		
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
13. I give permission for the de-identified transcripts that I provide to be archived in the Project Storage TU Delft repository so it can used for future research and learning.		
14. I understand that access to this repository is (restricted and may only be used when credited under the same licence (CC BY-SA)). The data in the repository will be deleted after 10 years.		

Signatures

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Name of participant	Signature	Date

I, as researcher, have accurately read out the information sheet tot the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Beyza Tokyay

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Researcher name	Signature	Date

II) Questionnaire - Consent Form

- Consent form: Opening Statement

Dear participant,

You are invited to participate in a research study titled *The Impact of Educational Real Estate on Enhancing Academic Performance*. This study is being conducted by Beyza Tokyay as part of a master's thesis within the Department of Management in the Built Environment at TU Delft.

The purpose of this research is to gain insights into how educational real estate and the physical learning environment influence the student learning experience of secondary schools' students. By understanding these dynamics, the study aims to provide practical recommendations for improving the design and use of educational facilities to better support student learning outcomes.

Your participation involves a 10-minute questionnaire where you will be asked questions about the role of the learning environment in influencing your experiences and academic performance. Your responses will contribute to academic research and may be included in publications related to this study.

To ensure your privacy, your responses will remain anonymous. No identifying information will be collected or stored during the study, ensuring that your answer cannot be tracked back to you. The data will be securely stored and used only for the purpose of this research.

Your participation in this study is entirely voluntary. You may decline to answer any question or withdraw from the study at any time, for any reason. If you wish to retract any of your answers or your participation in this research, you can do so within 14 days.

If you have any questions or need further information, please do not hesitate to contact me using the details provided below.

Thank you for considering participating in this research. Your time and insights are greatly appreciated.

Sincerely,

Beyza Tokyay
Delft University of Technology | TU Delft

Beyza Tokyay, BSc.
5235464

Delft, 28 October 2025
Master Thesis – TU Delft MBE