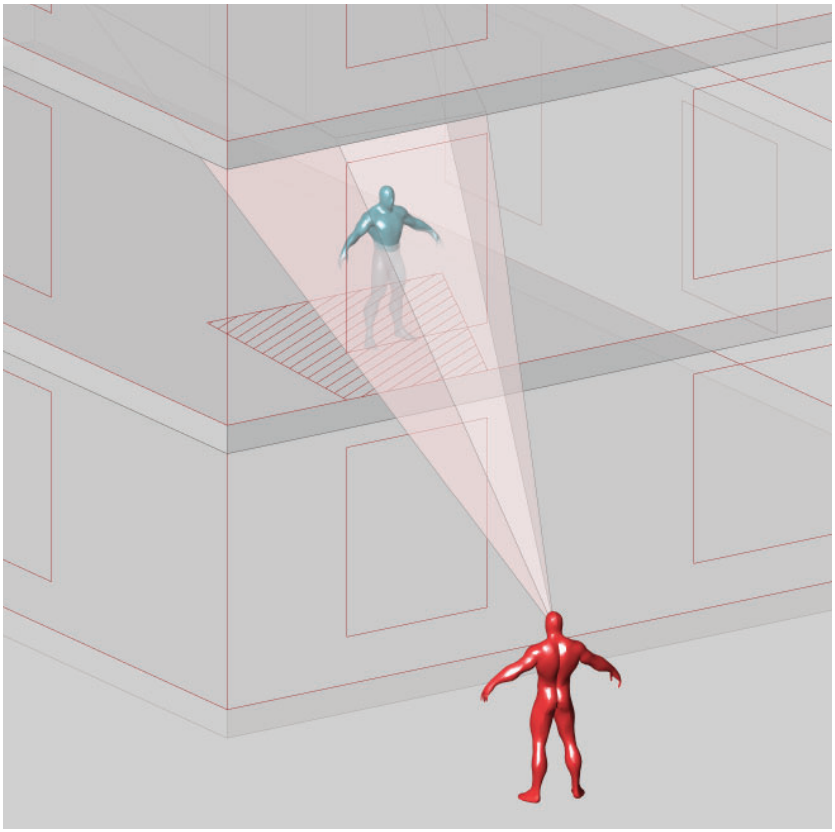
# Research Plan

## Architectural Engineering Graduation Studio
## 2022/2023



The potential of computational design to maximize spatial quality of student dwellings through informed decision making in the early stages of design


Personal Information:
**Reinis Melgalvis**
**4687663**

Design tutor:
Mauro Parravicini

Research tutor:
Michela Turrin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# ARGUMENTATIONS FOR CHOICE OF STUDIO

**Keywords**

Student dwellings, design optimization, spatial quality, performance evaluation, design decision support

**Argumentations for choice of studio**

My fascination in architecture is the potential of digital technologies to enhance our design processes in both making architecture of higher quality and also making the design process more efficient. I believe that architecture is both art and science, and we as designers should make these two worlds meet. Computational technology can provide tools that can help us better understand the impact our designs have on the environment and the related costs, but also spatial qualities that make them great buildings to live and work in. In this way our decisions can become more informed from very early stages of design, when the most influential choices are made. The graduation studio of Architectural engineering is technically oriented and the possibility to research your own topic of interest is the perfect opportunity for me to further investigate my fascination with the guidance of experienced tutors.

# PROBLEM STATEMENT

**Shortage of student housing**

There is a great deficiency of affordable student housing, and the demand is expected to increase in the coming years. Currently there is a shortage of over 25.000 student dwellings in the Netherlands, while the demand for student rooms is expected to increase by nearly 50.000 in the coming 8 years. From these dwellings over 5000 will be required in Delft (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021). This means that we have to build a lot of student dwellings and we have to build them fast.

**Insufficient spatial quality**

While the quantity of student housing is a prominent problem, the importance of spatial quality cannot be overlooked. As spatial quality of the dwelling has a direct impact on the well-being of the student, this should be addressed more explicitly in the design process. Factors such as views, privacy, lighting and spatiality among others have a direct impact on the perceived spatial quality by residents (Acre & Wyckmans, 2014). Furthermore, the quality of accommodation has a significant impact on the learning process of the student and their academic performance (Bello et al., 2018). As student dwellings are either studios or a room with shared facilities, usually they get windows on only one façade, meaning that if on this façade the daylight or view is not optimal, then there are hardly any design interventions that can be made to improve this.

**Early design stage decision impact**

Decisions made on early stages of design such as building shape and orientation will have a significant impact on the performance of the building including that of spatial quality (Gervásio et al., 2014). As much as 80% of the design outcome is influenced by decisions made during this time, while the relative time spent on this phase is rather short (Bogenstätter, 2000). Therefore, feedback required for informed decision making should be provided with minimal input so that multiple design alternatives could be compared explicitly and efficiently. Performance evaluation models can achieve this, while their implementation is predominantly adopted for environmental analysis rather than spatial quality evaluation (Yan & Kalay, 2005).

# OBJECTIVE

The objective of the graduation studio is to better understand what factors contribute to the perception of spatial quality in student dwellings and to develop a methodology to address this explicitly from early design stages. This will be approached through the development of a parametric performance evaluation model during the design process, that can be reused in different context in another student dwelling project. The goal is to make the analysis of factors that contribute to spatial qualities more objective, to enable more informed decision making in the process.

To support the design workflow, a performance evaluation model will be built to make repeated assessment of various design alternatives more efficient and their relative comparison more objective. Therefore, the research goal will be to determine what parameters play a role in the spatial experience of student dwellings and how can they be expressed in quantifiable values for objective comparison of design alternatives. While it is known, that views, privacy, lighting and spatiality among other factors influence the spatial quality (Acre & Wyckmans, 2014), the research will also attempt to express this further in various sub-parameters, for more extensive analysis.

The design, on the other hand, will work as a pilot project, that will not only be informed by the evaluation model, but also test it and provide feedback on the model itself for further improvements. In this way it will operate as research by design. The ultimate goal is to develop affordable student housing of high spatial quality through parametrically guided evaluation in the design process. The campus of TU Delft is a perfect location for this as the proximity to university is a commonly stated preference by students in the Netherlands (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021). Through reimagination of existing typologies and repeated spatial evaluation in relation to the context, the qualities of both private and collective spaces will be maximized.

# THEORETICAL FRAMEWORK

The aim of the research is to identify parameters that contribute to perception of spatial quality of student dwellings and construct a performance evaluation model that can be used in the design process. The framework defined by Kalay (Kalay, 1999), and further improved by Petersen and Svendsen (Petersen & Svendsen, 2010) will be used, where the workflow for performance evaluation in design has been defined for more informed decision making for early stages of design. In this model, computational tools are used for the evaluation of the design performance and to provide the designer with the necessary information to make required improvements.

The proposed workflow is illustrated in figure 1, where the first design model, based on implicit design knowledge of the architect, is evaluated gaining explicit values that can be used to compare different design alternatives. If the performance is insufficient, the issue is highlighted in the model, supplying the designer with information on both the location in design as well as the occurring problem. In this way, the impact of design decisions can already be predetermined before advancing to more detailed design stages.

Additionally, while the evaluation model will provide feedback to improve the proposed design, the process of design will also test the model, determining what kind of inputs are needed and if the results can be interpreted clearly for making changes in the design. Therefore, the iterative process will take place not only in design, but also in research and in the development of the performance evaluation model. In this way, the connection between design proposal and performance evaluation is iterated on two different levels, as both the proposed design is iteratively improved, but also the performance evaluation model.

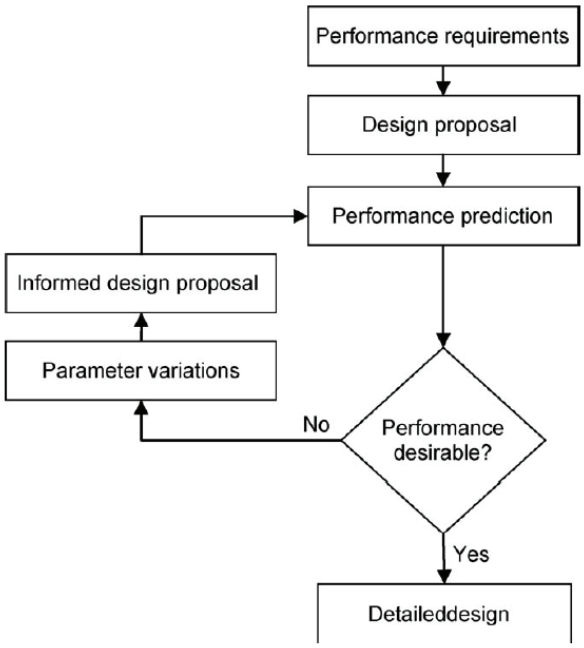


*Figure 1. Workflow performance based design developed by Kalay(Kalay, 1999), revised by Petersen and Svendsen (Petersen & Svendsen, 2010).*

# OVERALL DESIGN QUESTION AND THEMATIC RESEARCH QUESTION

**Overall design question**

"How can the spatial quality of affordable student dwellings be enhanced through extensive performance evaluation during early design stages in an increasingly densifying area of TU Delft campus?"

**Thematic research question**

"How can parametric performance evaluation model of spatial quality enable more informed decision making in early design stages of student dwellings?"

**Hypothesis**

By expressing spatial quality in quantifiable parameters, various design alternatives can be tested and compared to make more informed desicions as early as sketch design phase.

**Research sub-questions**

1. What variables play a role in the experience of spatial quality?
2. What design parameters affect the spatial quality variables?
3. What inputs are required in the design process to test and visualize the spatial quality?

# RESEARCH STRUCTURE IN RELATION TO DESIGN PROCESS

The proposed research sub-questions address the problem of spatial quality evaluation from more theoretical question of defining the spatial quality, to a very practical task of developing a parametric evaluation model, all with a goal to enhance the spatial quality of the designed student housing project. As the spatial quality is a result of the extensive amount of decisions made during the design process, the design parameters and performance variables can be seen as cause and effect relationship. The cause- design parameters can therefore be seen as an independent variable, affecting the value of dependent variables- evaluated spatial quality parameters.

While in the beginning design and research are conducted parallel to each other, ultimately, they become one, as many design variants are repeatedly tested and improved with the help of a performance evaluation model developed during the research. The process is illustrated in figure 2 on page 9, where the division in the phases of exploration, precedents and experimentation is made. Each research phase corresponds to a different research sub-question.

The exploration phase in research aims to define the spatial quality of student dwellings through extensive literature review. The goal of this part is to determine what factors contribute to an increased quality and what can be analyzed with the help of a performance evaluation model. Design tasks in this phase are to better define the site context and the built program.

Once the testable (dependent variables) have been identified, the precedent phase of the research will study their quality in existing student dwellings, with an objective to analyze what design parameters affect the variables of spatial quality. In this way, their relationship is defined, which is an essential task to build a computational evaluation model. The same cases and their typologies are also used and reimagined in the design process, using them as references to make first sketch proposals.

In the experimentation phase research and design becomes one. The studied relationship between design parameters and evaluation variables is adapted in a computational model, that is used to test some of the concept proposals to evaluate their spatial quality. The evaluation model is also developed based on the types of input that are available from the concepts. Therefore, the process of designing, making evaluation and implementing design changes occurs at the same time as the process of developing evaluation model, using it to test design variants and adjusting the model accordingly. This phase can be seen as research by design.

# METHODOLOGIES

As discussed in the research structure, the research will progress from more theoretical beginning, where the spatial quality and its factors will be defined in the context of student dwelling design, to more practical where a parametric evaluation model will be built. Therefore, in each part various research methods will be used.

Firstly, to better understand the aspects of spatial quality, literature review will be conducted to study the existing tehories of spatial quality. This will be supported by primary research through semi-structured interviews with students to gain further insights on their impression of spatial quality and variables affecting it.

Once the evaluation parameters have been established, case studies will be conducted in order to determine how design parameters such as circulation space, windows, building shape and orientation affect the spatial quality parameters. The aim is to establish a clear relatiobship between the independent design parameters and their effect on dependent spatial quality evaluation variables.

In the last part of teh research spatial quality evaluation model is developed based on the established relatonships between different variables. However, as the independent design parameters are the inputs required from design, The evaluation model must be developed in an itterative process, where it is repeatedly tested in design process and evaluated. Therefore experimentation in a form of research by design will be the applied as the research method for this part, to optimize both the designs and the usability of the evaluation model in practice.

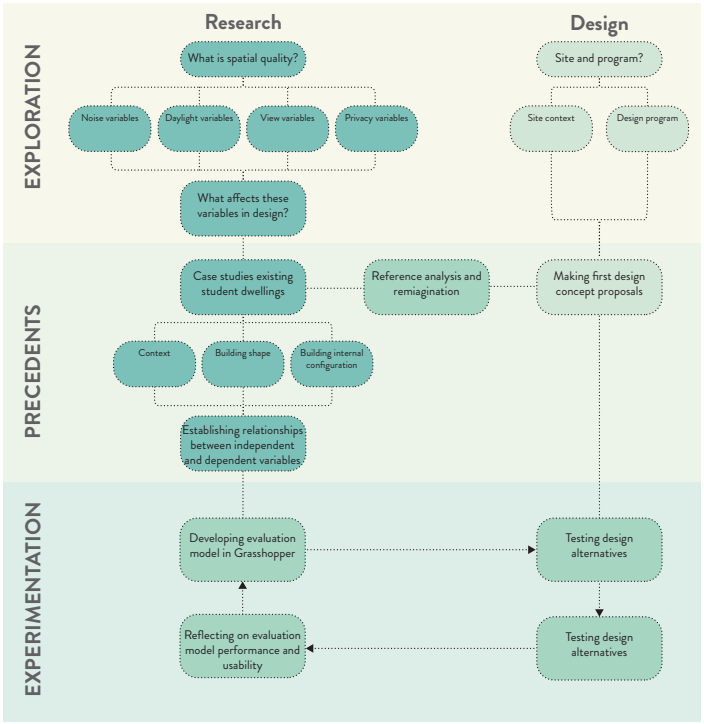


*Figure 2. Research structure from theoretical exploration to practical experimentation*

# RELEVANCE

The students are one of the most financially limited social groups, that reside in a relatively small area, usually limited to a single room. In this room they will spend between a third to half of their study life and therefore the spatial quality of this space will affect both their physical health (noise, daylight) as well as their mental health (view, privacy, daylight), which in turn has a great impact on their academic performance.

The spatial quality is currently addressed rather implicitly by architects and usually limited to just a few building regulations specified in Dutch regulations. These regulations are mostly limited to noise and sunlight that are tested during preliminary design stages, while their impact is heavily affected by building shape and orientation, which are primarily determined during conceptual design stage. To achieve higher spatial quality and gain more explicit insights, performance evaluation model can and should be used in the process to compare various design alternatives, enable informed decision making through data visualization and make adjustments at a relatively little effort.

# PLANNING

The visual timline below illustrates various design and research activities planned till P2 deadline, when preliminary design and research must be finished. Even though the research and design are separated in the scheme, they will mutually affect each other during the process.

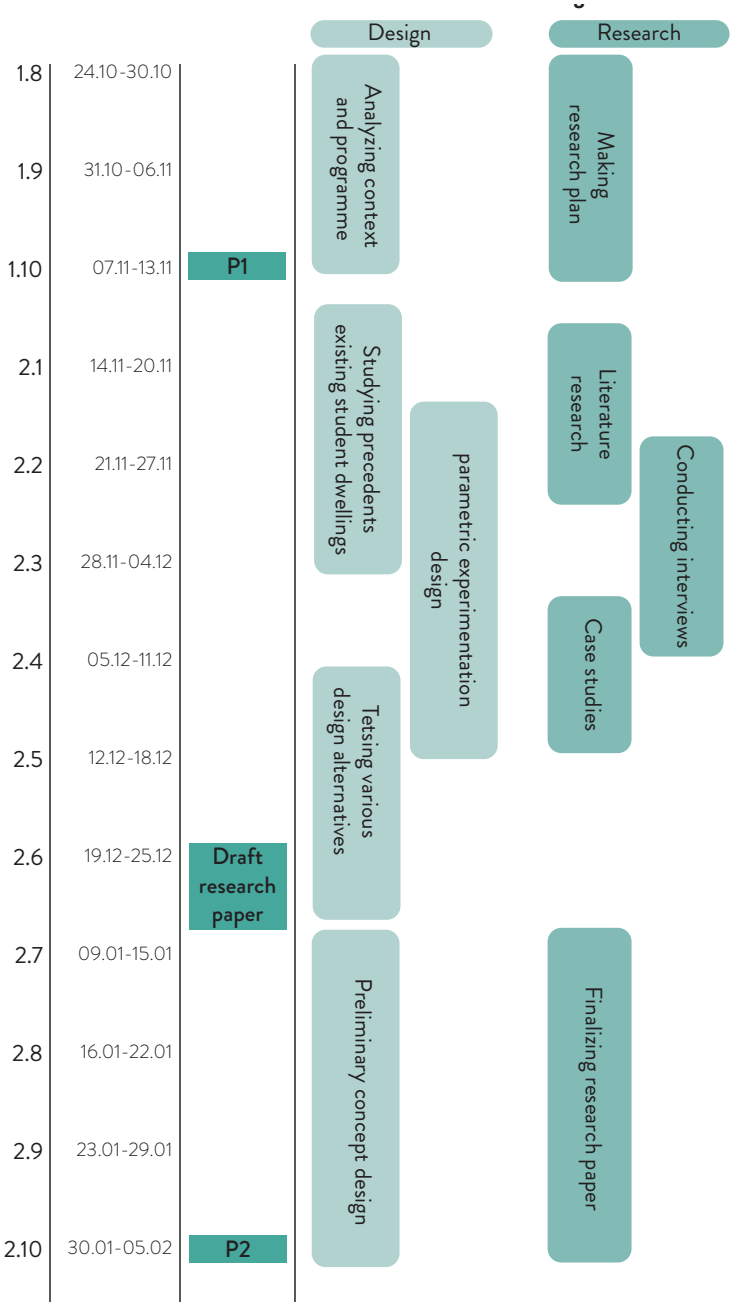


*Figure 3. Planning research and design until P2*

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