Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: Building Technology

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Meghana Raghunathan
Student number	5698901

Studio		
Name / Theme	Building Technology / Climate Design (Building Physics)	
Main mentor	Martin Tenpierik	Climate Design
Second mentor	Arie Bergsma	Product Development
Argumentation of choice of the studio	An ideal indoor environment is one where the user does not notice the Building Physics systems in place. Achieving this goal remains a substantial challenge for Climate Design, particularly in the field of Building Physics and its various sub-topics. Product Development presents itself as a viable avenue of approach to tackle this challenge of control of room acoustics in schools.	

Graduation project	
Title of the graduation project	Personalised Control of Indoor Acoustics in Middle Schools
Goal	
Location:	There is no specific project location. The resultant design will be tested by means of the simulation softwares CATT and Treble.
The posed problem,	In the wake of the pandemic, COVID-19, the hybrid learning system has seen an increase in popularity. This approach requires learners to work across multiple platforms, including online and in-person classes, as well as shared workspaces with simultaneous requirements. Newer teaching methods result in students working in smaller groups, breaking out, and re-joining the class at various frequencies. The different learning systems require different acoustic interventions, tuned specifically for the then-occurring function. The existing infrastructure is ill-equipped to manage all the challenges posed by the evolving modes of learning and necessitates either a complete rework or strategic interventions.

	The standards developed for schools are set based on the requirements of adults. This proves to be insufficient when one pauses to consider that children have still-developing auditory and sensory systems; they are more sensitive to certain noises and frequencies than adults. Poor acoustics has a long-term impact on children, affecting their memory retention, recall, language skills, and concentration in a classroom. Students require a steady acoustic environment that supports clarity of message and communication. In addition, mismanaged room acoustics of classrooms also result in an increase in stress and fatigue in teachers, with studies showing that they have a larger number of problems related to hearing and voice in comparison to the general population. Acknowledgement and remediation of the acoustic challenges posed by classroom acoustics can only result in an enhanced productivity of learners, and an improvement in the physical and mental health of both students and teachers, thus resulting in an environment conducive to the required learning activities that foster the next generation of thinkers and doers.
research questions and	"How do the various teaching styles, and the acoustic requirements of a middle school learning environment influence the implementation of acoustic control systems?" The following questions are used to elaborate and support the main research question. **Literature Research Questions:** 1. What are the different teaching/learning styles in a middle school? 2. How often are the different teaching/learning styles employed? 3. What is the influence of room acoustics on a student's/teacher's comfort and performance/productivity? 4. To what extent can providing control over a student's/teacher's room acoustic environment improve their task performance? 5. What type of acoustic measures exist to support users in their hybrid working systems? **Practical Research Questions:** 6. What are the key (acoustic) factors that play a vital role in evaluating acoustic comfort in (middle) schools?

	7. To what extent can users have control over their acoustic environment? 8. To what extent does acoustic control affect the (perceived) acoustics in middle schools? **Evaluative Questions:** 9. How affordable/accessible/user-friendly is the proposed acoustic (control) measure? 10. How does the proposed solution affect other indoor environment quality factors?
design assignment in which these result.	The outcome will result in a product that allows its users a specified degree of control over the indoor room acoustics. The design is tested by means of acoustic simulation software Treble.

Process

Method description

The research methodology consists of 6 parts, starting with literature research, continued by the research phase, and ending with the analysis of the research results.

Part 1: Research Framework

The research topic is analysed an evaluated on its contribution to the field of Building Technology and its relevance in the field of building physics. It is also analysed based on its impact on users. The research topic is also broken down into sizeable parts to ensure proper addressal of the sub-parts. This is used to determine the starting point of the literature research, establish a proper framework of research, and create a timeline of the entire process.

Part 2: Literature Research and Framework

Every good investigation begins with the establishing of facts, and that is exactly what this step of the research focuses on. It seeks to answer the various sub-questions brought forth by the research question and create a basis from which the research intends to continue. This theoretical portion covers the reading and analysing of conference papers, various reports, standards, books, theses, and products that have a relevance to the chosen topic in either the same field of study or in allied fields. These topics include the following:

1. Acoustic factors that determine room acoustic conditions
2. Problems faced by school students and teachers in terms of acoustics.
3. Psycho-acoustical analysis

4. Standards from around the world for schools and educational systems as well as for distinct types of learning systems
5. Advances in different teaching styles employed in the education sector.
6. Accommodations required for individuals with impaired hearing or additional hearing requirements.

Since at this stage the exact end product of the research is unknown, the literature research phase casts a wide net into the possible realm of topics and solutions. They are as follows:

1. System development
2. Product development
3. Research – architectural typologies

Part 3: Qualitative & Quantitative Research

The qualitative step of the research develops on the established facts of the previous step but can still be understood as part of the 'information collection' stage. It focuses on talking to industry professionals and quantitatively establishing a base comparison model for the testing of the design based on the data collected from the previous stages. It aims to put data to the emotional/psychological understanding of the studied space by means of digital simulation using CATT and Treble.

Part 4: Product Development

This stage takes all the data provided from the previous stages combined and puts it towards the development of a system that allows a user to control the application of the acoustic solution. It is developed and designed to address the unique needs of the indoor space under question.

Part 5: Product Testing

The developed product is constantly tested qualitatively and quantitatively using simulations carried out through CATT and Treble. This part also exists in conjecture with the previous and a back-and-forth process is expected.

Part 6: Results, Analyses, Conclusions

The last step of the research is to analyse the mountains of data accumulated by means of measurements and simulations. This data is visualised and interpreted, and conclusions are drawn based on it. This section also goes into depth about the limitations of the research and results, and potentials for further research/development are highlighted. It is the proverbial bow on the top of the research, here to tie everything up neatly.

Literature and general practical references

Offices

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Schools

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Other

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Reflection

1. What is the relation between your graduation (project) topic, your master track (BT), and your master programme (MSc AUBS)?

The topic "Personalised Control of Indoor Acoustics in Middle Schools" aims to address the lack of affordable acoustic control systems in educational environments by means of product development. It integrates the fields of Climate Design, particularly Building Physics and Product Development. The former provides all the necessary data regarding requirements, standards, users, and environmental limitations laying the groundwork for Product Development to advance. The latter uses the information gleaned from the former to offer solutions that address the established research gap in room acoustic control systems.

2. What is the relevance of your graduation work in the larger social, professional, and scientific framework.

In the process of researching topics in the field of building physics, I discovered that there was a severe lack of attention in the field of control over acoustics at the user level. It has been well established that users have a spectrum of requirements and definitions of personal comfort in any indoor environment.
This understanding has led to the development of control systems for the fields of ventilation, thermal comfort, and lighting. The control systems for acoustics are limited to either large-scale spatial interventions such as acoustic panels or personalized control systems such as headphones. There is limited research into dynamic passive interventions. Acoustic solutions are also not yet widely integrated into the everyday user's lives due to it being inaccessible, unaffordable, or simply not being user friendly. With the development of this research topic, I expect there to be a better product for the integration of acoustic control into everyday life. It aims to create an affordable solution to this problem. More importantly, it aims to set a foundation for further research in the field of controllable room acoustics.