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Education in Acoustics
Session 2pED: Teaching Methods in Acoustics

2pED4. Teaching acoustics at architect students using digital tools
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At the School of Architecture, Lund University Sweden, courses are taught in different ways. A large part of the education during year one and two is held as "studios", doing creative (individual) project work. Usually acoustics courses rather correspond to the traditional engineering education style, using lectures, exercises, small project works and final written examination. The problem is that many students don't know how to use the gathered information in their creative works. The aim of the study covered by this paper was to improve upon the existing teaching/learning of the fundamental acoustics principles scheme by introducing new methodologies. In order to achieve our goal, we gave the students two different assignments: In the first assignment, the students had to produce short educational movies to explain and teach acoustics principles to their peers. In the second assignment, they should implement the new knowledge gathered in the first assignment into their individual creative projects.

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TEACHING AND LEARNING SITUATION

The present study focuses on the situation we encountered in our very own environment. As such, it is about teaching common architectural language and tools to first and second year architectural students at LTH. We strive to teach our students the concepts of sound, form, light, color and construction, all orbiting around the common denominator of the architecture, see figure 1. The aspect of the communication is very essential to the work of an architect and it should be given a central role in the teaching experience.

An assessment of the current situation prior to this study reveals that there is a big gap between different types of learning within the Lund University, affecting the teaching and learning experience at the School of Architecture. Two types of teaching styles seem to coexist in years 1 and 2.

The first type, referred to as Special Courses in the following, consists of a series of four smaller courses (3 hp) extending over days or weeks. During fall, the courses are “intensive courses” during 2 weeks full time, whereas during spring the students have this type of course during one whole day a week. The courses are taught by guest teachers from other Institutes. Based on lectures and small assignments, they are followed by a written examination at the end of the semester. Focused on technical matters, they differ clearly from the students normal studios, which are more centered on creativity assignments. This hiatus causes some confusion for most students who seem to have little idea of why they have these special courses and how to use them in the creative assignments, especially in first and second year. Only the very best students seem to have the skills to connect and integrate the special knowledge in their own projects. The students often focus solely on how to pass the exam and not how to make use of this knowledge in their creative work. As a result of this lack of student connection and involvement, the retention rate of this kind of course is particularly low. This type of learning, in its actual form, is contra-productive as the class level is less than impressive compared to the students’ skills in general.

The second type of teaching methods, referred hereafter as the Studio, is very different. At the school of Architecture in Lund, first year and second year students are assigned to four different studios, with about 35 students (50% first-year and 50% second-year) in each studio. Each studio is led by a different teacher. When studio projects are started, the students are given an introduction to an assignment, followed by a short inspiration lecture. The students will be given a timeframe of one week to one month to produce a review where they have to present their model and drawings to a jury. The jury will comment and guide the student but no grades will be given. It’s up to the students’ daily teacher to follow and guide the students in their individual development. The students seem to make a rather compelling use of their studio classes to open up and integrate essential topics from the architectural field (light, construction, acoustics, material, colors, sustainability, building law, etc.).

Both teaching types lack any kind of homogeneity. The studio teachers and the special courses teachers originate from different institutes situated in distinct buildings at the University. We only meet once or twice a year and that is only for time planning meetings. There is little to no collaboration taking place for the creative assignments and the studios, as the teachers usually don’t meet for discussing teaching strategies or other pedagogic matters.

FIGURE 1: Common architectural language and tools.
PROBLEMS WITH THE FORMER TEACHING AND LEARNING SITUATION

Disparity in student background and skills

A class of students is more often than not a disparate group of individuals having different educational and personal backgrounds. Also at the school of Architecture, the student group is very inhomogeneous. Some students have just finished high-school, while others have been working for a few years. Also, the path leading to the school of Architecture differs from student to student: some obtained a place thanks to the good grades they obtained at high-school, others by their architectural portfolio. This disparity can be seen in the studio work already from year one: students who were accepted due to their portfolio have already architectural skills and understanding, which other students are mostly lacking. Regarding the special courses, the “technical courses”, there is also a large difference between students, most often depending on what kind of high-school they attended (focusing on social sciences, techniques, arts etc.) and on how long ago they graduated from high-school. In the first technical course, some students clearly feel unconfident when seeing an equation or having to manipulate numbers, whereas others ask for more “technical stuff”, equations etc. Under-stimulated students often don’t come to the lectures and might even drop out. On the contrary, students who lack the basic knowledge might not be able to grasp some particular aspects of the course content and while they are trying to make sense of the information, they might lose track and be left behind, unable to catch up with the course progress pace. Each missed concept or information will incrementally make it more difficult for them to keep afloat with the teaching material. This results in a different teaching situation, where the teacher does not really want to leave any student behind, but feels that he needs to do so for the sake of the group.

Having to juggle with the incompatible requirements from the audience is detrimental to the quality of the course, for both the students and the teacher. From the teacher’s point of view, this can be a stressful situation, where he must adapt in real-time the content of his message and his way of delivering it, depending on the reactions of his audience. Or the lack thereof, when he sees students drop their attention one after another. The diversity of background knowledge and skills has also the consequence that he has to be prepared for different scenarios, being ready to switch from the official course content to theoretical explanations about some basic background material that might be obvious for most of the audience but a few. He must therefore be constantly flexible and attentive.

In our particular case, the students acquire basic knowledge about basic topics within their years of studying. Former lectures may have addressed acoustics briefly or some students might have had a course in acoustics within their study plan, while others might not. As a teacher, it is particularly difficult to assess in advance how much a single student knows about the subject. Typically, clues about the relative experience of the various students start arising when the teacher notices that some individuals start having difficulties following the course of the lessons. Another issue for the students is to make efficient use of the material they study in separate courses. For example, courses about light, acoustics and construction are not always easily transferable to an architecture course.

One of the authors of this paper teaches the first technical course “Architectural Design” and has identified a clear problem with first year students who don’t understand some basic rules of structural engineering, stress distribution in beams and columns, force distribution in trusses. Without this simple background, it is obviously very difficult for the student to make sense of the more advanced concepts presented to him during the course. Another of the authors is studio teacher and has experienced that some students lack the vocabulary to describe their own projects or don’t know how to make use of things learned or heard in a parallel lecture into a description of their own project, or an analytic work on that topic. This is a very common issue of language and communication across related disciplines.

These exposed issues are critical for the following reasons:

- A set of basic concepts is necessary for a common understanding of architecture.
- A common language is a prerequisite for an efficient communication among the students on one hand and between the students and the teachers on the other hand.

The students need to have a rudimentary set of tools at their disposal in order to analyse existing architecture projects, as well as for making their own creations.
Engaging the students and adapting to sensibility disparities

Learning is an active process that requires the student to allocate a great part of his cognitive resources to the task over a long period of time. He first of all has to understand the material that is presented to him. Only when he is able to fully grasp what is presented to him can he elaborate a personal version of the information, in a format that he can make sense of. Once that step is done, he can memorize the material in order to be able to make use of this newly acquired information later on.

The first issue of the teaching model used for example in the special courses in Architectural program is that the student tends to be passive for a long span of time. For practical reasons, it is asked to him that he stands still, without talking, without interacting with his peers, without interrupting the course of the class. The passivity and the lack of movement over a prolonged period of time typically lead the students to a progressive loss of concentration, sometimes resulting in dozing off, yawning or outright falling asleep during the teaching lesson. We have unfortunately all witnessed those symptoms to some degree among our students.

We are not all equal in how we are best able to learn [2]. Some persons will be very sensitive to visual information, and will understand and remember concepts better when they are presented in drawings and pictures. Some others will better cope with information presented to them by speech. Yet some others will retain information the most efficiently when reading it, and will benefit from having a written support to follow on while the teacher speaks. Most would also argue that they need to put in practice some methods to better understand and memorize them, through problem solving for example. For others, however, repetitively applying the course content on various examples represents a complete waste of time. Biggs shows that if different learning methods (reading, hearing, discussing, applying, and teaching others) are combined, people learn more if only one method (e.g. reading or hearing) is used. As an example, in the course “architectural design”, most of the students have problems to understand how forces are distributed in a truss, i.e. which parts will be compressed and which will be loaded in tension. Different methods have been tried out to teach this subject: calculations on the one hand (which was hated by almost all the students) and more practical ideas thinking how the loads will travel through the truss and how the truss will deform. However, even if this method is used, not all the students understand. During the second week of the course, the students then work with a group project where they have to actually build a truss of wood and rods spanning 1 m, however the truss is not allowed to weigh more than 150g. The trusses are to be loaded with two point loads to failure at the project presentation. This weight limitation in this project results in an optimization work for the students where they use computer models, lecture notes and building small models to find the perfect shape for the truss and also to find out whether single elements in the truss should be made of wood (compressed members) or rod (tensioned members). Most student groups in the end produce trusses that can carry quite high loads and they write a paper explaining how they came up with their idea, telling how the truss works, etc. This is a typical example of that students learn by using different means (lecture notes, computer programs, model building), with the model building as a hands-on method being the most important part resulting in understanding. However, in the individual written exam at the end of the course, it can be seen that many students have difficulties to understand how trusses work, when they only work with paper and pencil.

The technical courses teaching model is characterized by a one-to-many configuration, where one person tries to transfer some information to many recipients in the most efficient way. By definition, since every individual is reacting fundamentally differently to his presentation of the course material, the teacher has always to make some compromises. It is not possible to deliver the message in a way that is optimal for each and every one of his students, so choices have to be made. From the student point of view, a stressful teaching situation is usually also felt by the students, who then have more troubles connecting with their teacher and establishing a trust relationship with him. The rigid format of the teaching methodology makes it difficult for the student to get efficiently and consistently engaged during the teaching course. The difficulties that have been evoked have little to do with the intelligence or cognitive capabilities of the students. The result is that some students may be disadvantaged when they have difficulties to cope with the teaching style, independently from their actual intelligence, skills and potential to learn. To some extent, it might be that their personal compatibility with the teaching style limits their ability to get fluent in the taught discipline.

Necessary changes

The teaching paradigm and teacher-student relationship as they have been described often prove to be impractical and not very well adapted in our experience. The format of teaching a “technical” class might benefit from a rethinking, the introduction of new models or an outright overhaul. For an efficient teaching and learning
experience to be possible, the students need to be engaged in the material, and not try to absorb it by passively attending the class. For this to be possible, some interactivity would need to take place. This includes both student-teacher and student-student interactions. By allowing mutual exchanges, the teacher can create an environment where all the students actively work on their understanding of the course, and help each other so that nobody is left behind. Each and every individual thereby regulates by himself the pace he needs for absorbing the content of the course efficiently. The format of the presented material also needs to be available under different forms that the various participants can absorb according to their particular abilities.

The background and skill disparity issue needs to be addressed. New methods of learning should be introduced, that are better adapted to a wide range of student profiles. As the basic course material is a prerequisite for the understanding of the more advanced parts of the course, a particular focus has to be shone on the bases, in order to secure that all students learn and understand these. While a rethinking of the methodologies is definitely a part of the solution, we will see that the introduction of some modern technologies can also contribute to solving the issues, in so far as they are used wisely.

In [4] the authors study the evidence of superior academic results, but also social and personal growth, when applying a Student-Centered eLearning (SCeL) teaching style. The problematic they focused on, is the limited amount of time a teacher can provide to their students. By using the computer for finding information they need for the course by themselves, the students benefit because the teacher can use the time allocated to each of them in a more valuable manner. The learning experience is thereby split in an autonomous period, where the students learn to work on their own and find the basic material they need by themselves, and an interactive period, focused on transparent, open, respectful and empathic interactions within the group. The students tend to estimate that they learn more in a same amount of time, independently from their initial level of knowledge. Furthermore, they learn to solve problems by themselves. The course attendance is higher because students are more involved and active.

In [3], the authors have a discussion about the role of the teachers in the “cyber-age”. According to their observations, the technology tools and internet are currently used by the teachers to increase the access to educational material rather than to improve the teaching experience in itself. Their reluctance to use the technology even more is reported to result from a lack of training and infrastructure. The authors suggest that adequate tools could help both the teacher and the students to get an even better experience. They propose a research tool based on semantic questioning instead of just keywords for retrieving relevant information.

THE GOALS WITH THE TEACHING/LEARNING SITUATION

We would like to improve upon the existing teaching/learning scheme by introducing new methodologies. Based on the evaluation of the current situation, we strive to achieve the following objectives by the end of the teaching period:

Each and every student should have a very good understanding of the basic concepts and techniques that underlie the field of study, and this whatever their initial academic and personal background.

The students should master the commonly accepted and used vocabulary for the field of study. Thereby, they will be able to understand and be understood by their peers and professionals. Sharing a common set of terms is essential for communicating efficiently and precisely.

Each student should master a minimal set of skills, methods and tools that they will have to rely upon as a solid basis for their future professional work.

The students should be able to efficiently use modern communication technologies. This will give them a head start in a world where the said technologies are likely to play an increasingly crucial role and to evolve quickly.

ACTIONS TAKEN

Introduction of new methods

A new type of assignment has been introduced. The students, organized in small groups, were given the task to create short movies on basic topics using various media, including but not limited to: written text, sounds, still pictures, movies and animations. The result of their work would be shown to the other students and to the teacher.
strong emphasis had to be put on conveying the message clearly to the fellow students, to make it easy for them to understand. By working on this objective, they should create a common understanding and language.

We began by showing the students the results of similar assignments, in the form of audio files or movies found in podcasts or video sharing platforms (YouTube, Vimeo…). The examples were intended for showing the students what is required from them. A typical example presented to them was a sound file demonstrating the concept of a soundscape.

The project has to be conducted seriously and requires a thorough investigation of the subject. It typically involves a lot of research, reading and the analysis of existing work, for example buildings erected by experienced architects. The resulting video must constitute an educational material on the given subject. As such, it should be clearly understandable by the fellow students and convey enough information for them to learn some new material and acquire valuable knowledge and insight in the topic, whatever their background was.

The topics addressed in this assignment include:

- Acoustics and sounds
- Construction
- Shapes
- Colours
- Movement
- Textures and materials
- Light
- Scale
- Rhythms
- Hierarchy
- Perceptions (light versus heavy, dynamic versus static, …).

Some of these topics are to be found in Sten Eiler Rasmussen’s book “Experiencing architecture” (1957). Therefore, we would like to create a new experience of learning these basic topics, based on modern media.

Having the students working in groups on this kind of assignment has several benefits. First of all, the students really engage into the activity. They have to rely on themselves and their friends for the work to be done. And more importantly still, their friends count on them for doing the tasks they have been assigned to. This responsibility means that they cannot afford to be passive. They have to work actively towards their objective.

Having to produce an educational material means that the students have to understand clearly the content of their production beforehand. If there are flaws in the comprehension of the topic, they will be inevitably laid bare during the production of the video, when there is still the possibility to dig deeper into the topic, to discuss and research until an appropriate level of understanding has been reached. This means that no one is left behind, each student will ultimately gain a good knowledge of his topic. Students that start with an advantage because they have former knowledge of the topic can help their fellows by sharing their skills. While doing so, they will most probably deepen their understanding even more and gain confidence and pride. The learning process is enhanced for all the students, whatever their initial level.

Presenting the material with their own words is a great communication exercise for the students. Our hypothesis is that it will help them acquire and master the appropriate vocabulary for the field they are working on. It will also open their minds to new perspectives when confronted to the diverse points of view of their fellow students. Having to defend their position will result in more self-confidence.

The teacher, meanwhile, also benefits from the process. Our hypothesis is here that the assignment implies mutually helping each other, so the teacher is less likely to have to explain all the content of the course material down to the very basics, as more experienced students will take over the task to help the more inexperienced of their peers. This most probably will result in significant time saving and a reduced stress level.

**On the importance of the used tools**

Modern media and new technologies are here not used as a goal in themself, but rather as a tool to achieve the expected educational goal. Producing a video is a multi-disciplinary activity and will teach them new skills. The very nature of the media to be used means that they will gain experience in using modern communication technologies. Furthermore, it is a perfect setup for learning the benefits of teamwork, a skill they will likely prove
beneficial in their future professional activities. Working on a case study requires being strict and following some logical path. They will thereby learn to work in a more structured manner.

The visual aspect is a primordial part of the architect’s work. Working with illustrations can for example put in evidence how a structure is affected by tension. Having the students to produce an audio-visual content will be beneficial for them, as it will get them used to think and work with visual clues. Pictures and images also play a vital role in communicating about their work with customers. Less obviously at first thought, acoustics, lights, colours and shapes are also parts of a panel of tools an architect can use to communicate with.

**METHODS TO ASSESS THE CHANGES IN THE TEACHING/LEARNING SITUATION**

Contrary to scientific and technical disciplines, architecture is suited for a precise measurement of the skills only in a limited subset of material. It is thereby difficult to precisely assess the changes introduced in the teaching and learning situation by using traditional metrics.

Letting the students express themselves on the studied material, explain what they have learned and describe their experience, is however a very good way to measure the development of the students’ skills as a result of the assignment. This is however a subjective measurement of the change. One more systematic way to investigate this would be to use the taxonomy scale proposed by Bloom, grading the students accordingly before and after the second assignment to see if they improved.

Another way could be to ask the students to evaluate their peers, the work they have produced, the progress they have made. Organizing a friendly competition where each student is both alternatively judge and judged could for example give them the opportunity to have a critical view at each other’s work and to learn even more in the process.

Great consideration has to be given to the fact that the teacher still has the responsibility to permanently assess the progress of the assignment and support the students, in case they would need it while working on the assessment. A team of students might for example have the illusion of doing all right while moving in a wrong direction or producing a substandard quality product. A continuous evaluation of the progress should therefore take place, allowing for small adjustments in the course of the project.

**RESULTS**

The evaluation of the results consists of two parts:
- The movie (using digital tools)
- Implementation of new knowledge in individual projects

The fact that the students in this assignment are either first or second year students is taken into account in the evaluation.

**Movies**

*The teacher’s evaluation*

The students surprised us by how enthusiastic they were in their work and did a great job overall. The particular approach of studying of each individual could be recognized very clearly by the way the movie was worked on. Some of the students concentrated on seeking deeper knowledge and using the newly acquired knowledge for their assignment. Some others took liberties and provided a more creative answer to the assignment, not caring too much about the technical information that was requested.

*The student’s evaluation*

We had a half hour talk with the students to discuss about what they did and their experience on the assignment. The outcome of the movie experiment was very satisfying in general. Even though there are some inevitable disparities, everybody learned something and produced a movie that explained their topics in a more or less artistic
The students shared during the evaluation that they enjoyed making the movies and asked for this kind of assignment to be repeated in the future.

They appreciated the challenge of collecting knowledge about different areas and communicating it, found it very stimulating, since they had the freedom to be creative and to make their own style for this communication. They also appreciated to have the total liberty about the choice of style, computer software, formats (movies, stop motion movies, slide show, voiceover, music etc.).

**Implementation of New Knowledge in Individual Projects**

This aspect of the assignment was centered on evaluating the students’ ability to implement this new knowledge into their own creative assignment. The topic was the remodeling of an existing building into students living units. The students should focus on three topics: structure, acoustics and one more topic of their choice from the movies, see figure 2.

BASIC TOPICS IN ARCHITECTURE

![Diagram of Basic Topics in Architecture](image)

**FIGURE 2:** Basic topics in architecture to be implemented in the creative assignment.

*The teacher’s evaluation*

In this part it became very clear at which general level the students were, according to Bloom’s taxonomy. The students who normally would be at a higher taxonomy level also seemed to integrate an implementation of the gained knowledge from the first assignment. There was also a very clear difference between first and second year students, besides a few exceptions. It seemed like the first year students, who were not trained in the creative process, had enough to do with understanding the assignment, getting an idea about how to turn their ideas into images, and tended to forget about the implementation of acoustics and construction. Only a very few of the first year students addressed acoustics issues in their projects. There was a very clear new focus on light and its quality, however, which had not been addressed before in this level. In addition, light construction was addressed in more projects, but they didn’t seek the experts’ support that was offered to them, and the results were mixed.

*The student’s evaluation*

A half hour talk was held with the students, about what they did and their experience on the assignment. The students seem to find that acoustics issues are more diffuse to work with. They didn’t find they had enough time to address this and gave the topic a lower priority. They found they needed more information on materials, sound waves, etc. and did not use their time to find it by themselves. They said they were very stressed about this part. They had the opportunity to meet an expert on the field but only a very few made use of this offer.
CONCLUSIONS

In general the first assignment worked much better than the second assignment. The level was satisfying and the students seemed to like the challenge. In the second assignment only the best students managed to address the topics, while only a very few really impressed us. Most students only produced a mediocre job.

It seems that there could be a grading in the topics, where some would be introduced in first year (light, color, simple constructions, etc.) and others in the second year (detailed construction, acoustics, etc.). In addition, the courses should be planned in a way where a much closer and more frequent contact with experts occurs and all students have scheduled meeting with these experts.

REFERENCES