



Interdisciplinary Course Smart Building Engineering: A new approach of teaching freshmen in remote teamwork project under pandemic restrictions

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Abstract

In the context of the Corona pandemic and its impact on teaching like digital lectures and exercises a new concept especially for freshmen in demanding courses of Smart Building Engineering became necessary. As there were hardly any face-to-face events at the university, the new teaching concept should enable a good start into engineering studies under pandemic conditions anyway and should also replace the written exam at the end. The students should become active themselves in small teams instead of listening passively to a lecture broadcast online with almost no personal contact. For this purpose, a role play was developed in which the freshmen had to work out a complete solution to the realistic problem of designing, construction planning and implementing a small guesthouse. Each student of the team had to take a certain role like architect, site manager, BIM-manager, electrician and the technician for HVAC installations. Technical specifications must be complied with, as well as documentation, time planning and cost estimate. The final project folder had to contain technical documents like circuit diagrams for electrical components, circuit diagrams for water and heating, design calculations and components lists. On the other hand construction schedule, construction implementation plan, documentation of the construction progress and minutes of meetings between the various trades had to be submitted as well. In addition to the project folder, a model of the construction project must also be created either as a handmade model or as a digital 3D-model using Computer-aided design (CAD) software. The first steps in the field of Building information modelling (BIM) had also been taken by creating a digital model of the building showing the current planning status in real time as a digital twin. This project turned out to be an excellent training of important student competencies like teamwork, communication skills, and self-organisation and also increased motivation to work on complex technical questions. The aim of giving the student a first impression on the challenges and solutions in building projects with many different technical trades and their points of view was very well achieved and should be continued in the future.

Keywords: Freshmen, roleplay, Smart Building Engineering, BIM, remote teamwork

1. Aims of the project

For most freshmen it is a complete new period of life when they start studying: Many of them move out of home for the first time and come to new places without knowing the other students. They are suddenly responsible for themselves and have to structure their new everyday life on their own. More than two thirds of freshmen have problems to organize themselves and prepare exams efficiently in the beginning. Many of them also struggle with performance requirements and need help with written homework [1], [3]. Corona pandemic also reinforces these problems: There is hardly any face-to-face events at the university allowed because of pandemic restrictions and many students feel lost and lonely sitting in front of their online lectures and digital exercises [2]. To provide a good start especially for freshmen anyway in demanding courses of Smart Building Engineering a new teaching concept became necessary. One of the aims was to get the students into contact with each other actively in small teams. Another aspect of the project was the training of important student competencies like teamwork, communication skills and self-organisation right at the beginning of the course. Also the motivation to deal with complex technical questions should be increased.

For this purpose, a roleplay was developed in which the freshmen had to work out a complete solution to the realistic problem of designing, construction planning and implementing a small guesthouse in the builder's garden. Each student of the team had to take a certain role like architect, site manager, BIM-manager, electrician and the technician for HVAC installations.



2. Requirements for the new interdisciplinary teaching concept

The freshmen should understand the interdisciplinary concept of the course “Smart Building Engineering” in general. As part of the module "Integral Planning and Building" for freshmen in the course this project should give them a first impression on the challenges and solutions in building projects with many different technical trades and their points of view. The students should get to know the different problems that arise from a construction task for the involved technical disciplines. They should understand the relevance of a good coordination of the individual contributions for the success of a construction project. Therefore, they had to recognize essential interfaces and interactions in the area of planning and execution.

The project should not just bring the students into contact with each other it also should promote their creativity. Therefore, the project had to be set up in an open way leaving enough space for creative solutions instead of resulting in a single “correct” solution. In order to be able to evaluate the project folder fairly and transparently at the end, minimum requirements had to be set for the task execution.

Because of social distancing during Corona pandemic, this project should also replace the written exam at the end. The freshmen had to submit a project folder containing technical documents, documentation, time planning, cost estimate and minutes of the meetings between the various trades.

A model of the construction project must also be created either as a handmade model or as a digital 3D-model using Computer-aided design (CAD) software. The first steps in the field of Building information modelling (BIM) had been taken by creating a digital model of the building showing the current planning status in real time as a digital twin as well.

3. Design of the new roleplay

The development of the new roleplay was challenging: On the one hand, the task should be complex enough so that all aspects of a complex building project occur realistically. On the other hand, it should leave enough room for creative solutions and not overwhelm the freshmen with its scope and complexity. The task also should be designed in such a way that it can only be solved successfully if all team members work together. Therefore, the students had to form teams of 4 to 5 members and each team member had to take a certain role. For each role a specific task was defined with just few technical restrictions to the possible solution. For each role and their tasks some simple instructions, examples and templates were given for getting an idea of how to solve the problem.

Requirements for the guest house	
Maximum floor space of the guest house	30-50 m ²
Maximal height	not two full floors
Functional areas that should be included	living area
	kitchen area
	dining area
	bathroom
	sleeping area with up to 4 beds (fixed or variable)
	storage space
	terrace
	office area

Table 1: Overview of the minimum requirements for the guest house in the client's garden.

In order to ensure the exchange between the team members, the students must meet regularly for digital meetings and also take minutes. In this way, joint decisions were recorded and the progress in the project was documented. These minutes were also part of the documents the students had to hand in for grading their group work.

Role	Main tasks
Architect	Design the guesthouse and its rooms/areas.
	Create a floor plan, views, and sections on a scale of 1:20.
	Create a model (handcrafted or digital 3D-model using CAD software).
Site Manager	Monitor and coordinate the work / elaboration of all processes.
	Plan every step using a construction schedule.
	Check the elaborations of the others and document them in



	minutes.
	Deal with project management, regulations and safety on the construction site.
	Cost estimation and controlling.
	As the person responsible, compile the documents for the final acceptance.
BIM-Manager	Advise the building owner about the possibilities / advantages of BIM applications.
	Monitor all planning steps.
	Define the digital planning tools and request input from all involved trades.
	"Maintain" the 3D model or the digital twin of the building.
Electrician	Plan the number and location of sockets, power lines and lamps.
	Create a sketch / plan on a scale of 1:50 (no expanded circuit diagram) with a legend.
	Information and communication technology.
	Alarm system.
Technician (HVAC installation)	Planning of sanitary facilities, hot water supply, ventilation (for bathroom, kitchen).
	Plan the inlet and outlet pipes.
	Dimensioning of the required components.
	Create a sketch / plan on a scale of 1:50.
	Determine the approximate material required.

Table 2: Overview of the tasks for each role in the roleplay.

4. Implementation and results

The Freshmen formed 8 teams (two teams with four and six teams with five members) independently and signed up for the project via E-Mail up to a deadline. All the required specifications and the task definition were made available via the ILIAS [5] platform. All teams could start their projects at once. The students had 4 months to work on the project and to put together a project folder with the required documents at the end. The files were also submitted digitally via E-Mail or data exchange tools because of social distancing. The groups that decided to build a physical model instead of a digital 3D model were allowed to photograph their model for project folder submission and hand it in later on. Because of extended corona restrictions during lockdown in Germany at the beginning of 2021, this project replaced the final written exam in this module. The submissions were graded and all group members together received the same grade for this module.

In case of questions or problems the students had the opportunity to contact three peers. Some asked questions during the projects primarily to ensure that their solution met the requirements, but just very few teams needed further help.

Some groups faced the problem of one group member dropping out during the project. In this case, it was assured that the group can still take part in and will not be disadvantaged because of the missing parts in the grading. Some groups had that much fun with their project, that they unceremoniously divided all open tasks among themselves. In this way, these teams brought their roleplay to the next level by playing more than one role at the same time. Of course, these students got to know several different perspectives and recognized even better the importance of interdisciplinary approaches and binding agreements between the various trades.



Figure 1: Front view of the 3D model (top left), open top view of the 3D model (top right), floor plan (bottom left) and installation plan of one of the groups [4].

5. Outlook

The Freshmen who took part in the project gave consistently positive feedback: In times of lockdown, many were grateful for a task that made it easier for them to get into contact with the others. Despite the Corona restrictions, they got a good start to their studies based on the required cooperation in their teams. Most students also found it more interesting to independently deal with typical problems during a planning and construction process than simply listening to a lecture. All this leads to a better understanding of the goals of this interdisciplinary course and have a more precise idea of their possible future professional life.

This project turned out to be an excellent training of important student competencies like teamwork, communication skills, and self-organisation and increased motivation to deal with complex technical questions. The aim of giving the student a first impression on the challenges and solutions in building projects with many different technical trades and their points of view was very well achieved and should definitely be continued in the future.

6. References

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