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Digital Planning Using Building Information Modelling and Virtual Reality: New Approach for Students' Remote Practical Training under Lockdown Conditions in The Course of Smart Building Engineering

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Abstract: The worldwide Corona pandemic has severely restricted student projects in the higher semesters of engineering courses. In order not to delay the graduation, a new concept had to be developed for projects under lockdown conditions. Therefore, unused rooms at the university should be digitally recorded in order to develop a new usage concept as laboratory rooms. An inventory of the actual state of the rooms was done first by taking photos and listing up all flaws and peculiarities. After that, a digital site measuring was done with a 360° laser scanner and these recorded scans were linked to a coherent point cloud and transferred to a software for planning technical building services and supporting Building Information Modelling (BIM). In order to better illustrate the difference between the actual and target state, two virtual reality models were created for realistic demonstration. During the project, the students had to go through the entire digital planning phases. Technical specifications had to be complied with, as well as documentation, time planning and cost estimate. This project turned out to be an excellent alternative to on-site practical training under lockdown conditions and increased the students' motivation to deal with complex technical questions.

Keywords: Smart building engineering, Building information modelling, Virtual reality, Lockdown conditions, Remote practical training

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Introduction

The worldwide Corona pandemic and its consequences on teaching like online lectures and remote exercises had also severely restricted student projects in the higher semesters of the interdisciplinary course “Smart Building Engineering” in Germany. Usually there are practical trainings in the industry intended the 5th and 6th semester of this course to get the students into contact with industry partners for gaining first practical experiences. Unfortunately, it was not possible to implement these plans because of Corona pandemic restrictions.

For not delaying the completion of the studies by missing projects, a new concept had to be developed for projects suitable to actual lockdown restrictions in Germany: There were only online lectures and hardly any students at university allowed for avoiding physical contacts by social distancing. Therefore, it had to be possible to work on the new project from home or with remote access. In addition, it should be a real problem rather than another sample project. The students should be able to apply realistically what they have learned so far in the field of digital planning of smart buildings and technical services.

Method

Current state of the rooms

For creating a new realistic remote project, rooms at the university that had not been used for a long time should be digitally recorded in order to develop a new usage concept as practical training and laboratory rooms for the new course Smart Building Engineering with current plans. Due to the long vacancy and the new requirements, some changes and renovation measures were necessary. The area under consideration consists of several rooms and corridors on two floors (cellar and ground floor). In the first step, an inventory of the actual state of the rooms was done by taking photos and listing up all flaws and peculiarities. The students also had to deal with questions concerning structural contaminated sites such as chlorinated diphenyls or asbestos and entrances to an adjacent air raid shelter from the 1960s that must remain accessible.

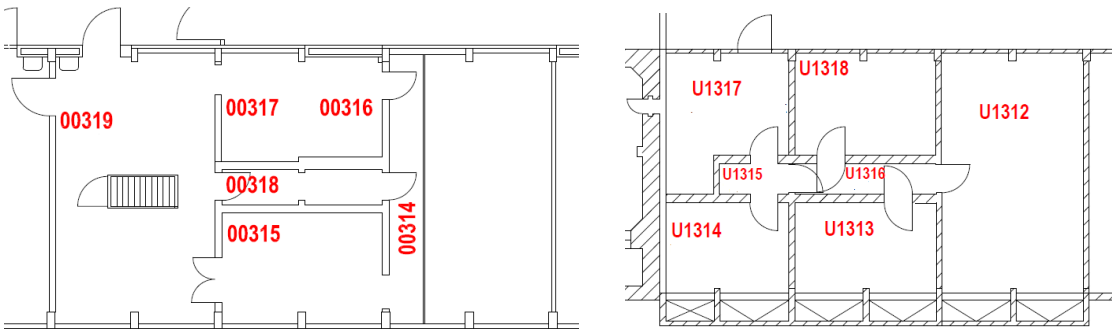

Figure 1. Plans of the rooms on the ground floor (left) and cellar (right), own representation

Workflow in the project and used hard- and software

Since there were no more usable plans for these rooms, a digital site measuring was done with a Leica BLK360 laser scanner by one of the students within one day [1]. In the next step, this recorded data was processed using the Leica BLK360 Manager software to download the raw data from the scanner [2]. These raw data than were processed into point clouds with special reality recognition software Cyclone Register room by room [3]. The software Autodesk ReCap was used for clearing the point clouds [4]. Later on, these data were transferred to the software for planning technical building services Autodesk Revit also supporting the technology of Building Information Modelling (BIM) [5]. All rooms were merged into floors than, so the planning phase could start in a complete three-dimensional model of all rooms together. The Revit plug-ins of the Alpi Caneco software BT 2020 and BIM 2020 were also used for planning and dimensioning of all electrical components because Revit has no option for electrical planning [6] ,[7]. Following, a three-dimensional model was created from the imported data in Revit, in which the complete technical design of components was implemented. In order to better illustrate the difference between the actual and target state, two virtual reality models should be created so that the difference can also be "experienced" with virtual reality glasses by using the software Enscape [8].

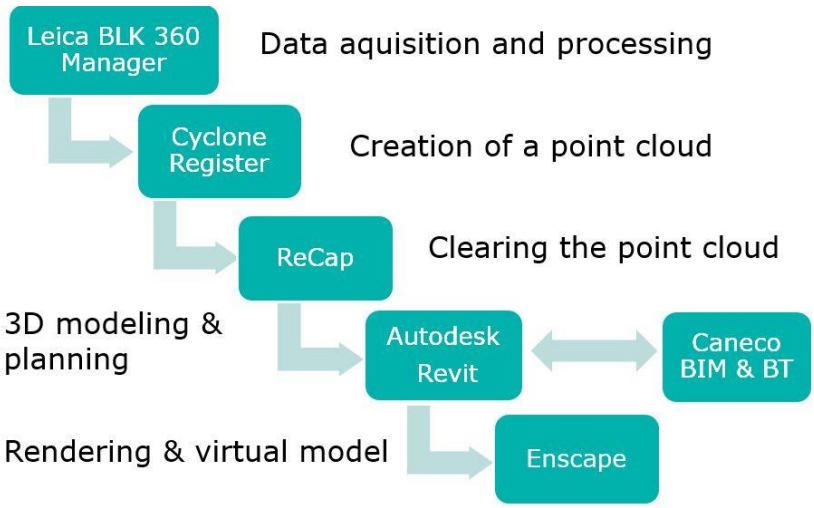

Figure 2. Overview of the workflow, the software used and the work steps, own representation

Results

During the 5 months of the project, the students had to go through the entire digital planning phases. Technical specifications had to be complied with, as well as documentation, time planning and cost estimate. Because of extended corona restrictions during lockdown in Germany at the beginning of 2021, this project replaced the final written exam in this module. Therefore, the project folder had to contain technical documents like circuit diagrams for water and heating, circuit diagrams for electrical components, design calculations and components lists. Construction schedule, construction implementation plan and minutes of meetings with the peer had to be submitted as well.

Figure 3. Example of one of the rooms and the results: Photography of the actual state in the beginning (top left), recorded point cloud data (top right), three-dimensional model for planning purpose in Revit (bottom left) and three-dimensional virtual reality model in the target state (bottom right), own representations.

Discussion

In this project it became obvious, that good computer equipment and a good internet connection are necessary for data rendering because of the high amount of data. Some students had to wait longer for data exchange, model computing and loading of technical components' databases via internet depending on their internet connection. To solve this problem, a remote connection to powerful stationary computers in the university was established and could be used the students in order to handle the big amount of data. In this way all students managed to succeed and set up their three-dimensional models. One example is shown in the following figure 4.

Figure 4. Overview of the target state of all rooms together including furniture and technical equipment, own representation.

Conclusion

This project turned out to be an excellent alternative to on-site practical training especially under lockdown conditions and the students gave positive feedback at the end of the project. It increased the students' motivation to deal with complex technical questions by giving them a real problem. Most students also found it more interesting to independently deal with typical problems during a planning and construction process than simply listening to a remote lecture or waiting for lockdown to end. The possibility of finally being able to "experience" the result as a virtual 3D model via the Internet was an interesting and instructive conclusion to the project for the students. This also helped a lot the visualization of possible mistakes, because they are more obvious in a "realistic" surrounding than on plans and technical drawings.

Recommendations

This type of remote team work could also be an interesting alternative to on-site practical training even after Corona pandemic. The students learnt to struggle planning problems in a more realistic way on their own as it is needed in future jobs. The option to discuss problems or questions with a peer in regular periods was obviously

helpful and should be continued in future. This mode of working could be a good training for future working situations in mixed teams in larger companies having people in office, travelling or on the construction site.

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