Teaching architectural history through virtual reality

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ABSTRACT: The impact of implementing 3D models and virtual reality in teaching the theory of architecture and architectural history is the theme of this article. Virtual reality and easy-to-use 3D tools allow a whole historic object to be visualised. As a result, there is social and economic pressure to modernise present educational methods using this technology. Therefore, the authors have focused their research on an issue of significance today: how the newest digital technologies might influence the development of students' technical skills and their abilities for logical thinking.

INTRODUCTION

New technologies raise the issue of whether human spatial imagination might be replaced by digital tools. There is increasing pressure to use 3D digital tools; for example, in building information modelling (BIM), which provide new opportunities in the design process. However, 3D digital tools may limit the traditional methods of students' hand-based work, such as sketching, drawing and building models [1]. This situation drains the enthusiasm of some scholars and provokes scepticism in others. The aim of the authors' research was to check whether the implementation of virtual reality may impact the effectiveness of teaching the history of architecture. Digital models are commonly used in presenting historical monuments and museum collections, but there is little work that investigates the usefulness of virtual reality for the layman *vis à vis* professionals.

Digitisation is now a feature of architectural education. Most students today apply BIM technology in project design [2]. Many disciplines related to architecture, such as archaeology, use 3D modelling and virtual reality for visualisation [3-6]. An interesting technology is CAVE (cave automatic virtual environment: a recursive acronym), which produces an immersive 360 degree view of an object. Virtual reality enables the visualisation of architectural objects (built/unbuilt, modern/historical) in any location, which encourages its use in architectural history education [7][8]. Photogrammetry can produce an extremely accurate inventory of an object, which then can be used as a basis for creating virtual reconstructions of the object of use in education [9][10].

METHODOLOGY

The authors previously have carried out *one-off* investigations with groups of students from the fourth term in the Faculty of Architecture at Gdańsk University of Technology (FA-GUT). Because of potential uncertainty of the results from such singular investigations, experiments were conducted on two groups, during February 2020, to compare the effectiveness of teaching through traditional drawing exercises and drawing exercises with the help of digital tools [11].

Typical drawing exercises in the History of Polish Architecture course depend on students individually constructing an axonometric view, perspective or section of a selected historic building. During class, they are presented with several photos and historical plans of the object. The students' task is to propose a possible and probable spatial representation based on the material provided by the tutor (sometimes there is more than one correct answer). Thus, the exercise combines the student's knowledge with manual skills and spatial imagination.

The aim of the course is to teach the students:

- analysis of function, construction, detail;

- estimated dating and architectural style of the object;
- elementary knowledge of the history of Polish architecture and objects (e.g. churches, castles, cities' urban layouts);
- skills that will allow the students to create a correct historic inventory of a given object [12].

Each year, the tutors change some topics to avoid the possibility of students reusing older works. The exercise focuses on logical thinking and unfair co-operation between students (such as cheating, redrawing, using the Internet during classes) is strictly forbidden. The History of Polish Architecture is regarded as one of the hardest subjects to pass at the FA-GUT.

Drawing exercises, with or without digital tools, originally were expected to be similar. The only differences were the materials provided by the tutor; photos and a plan of the historical building when drawing without digital tools and a digital 3D model of the historical building when drawing with digital tools [13]. Students in two groups, with and without digital tools, had to draw the same picture. The two groups were kept separate.

It was necessary to ensure that the groups were representative of the whole class. To achieve this, the authors decided to randomly divide the students into two groups for a first experiment and swap their positions for a second similar experiment. Students did not know they were being divided into separate groups and had to participate twice in a similar experiment. After the classes, the drawings from the two groups were mixed and anonymously evaluated by a tutor, who did not know their provenance. The experiments are described below.

EXPERIMENTS

During the experiments, the students had to create a *structural drawing*, a sketch of a historical construction (axonometry or section) [14-16]. The students from both groups received a description of the task and a briefing about the evaluation process including quality criteria. Students were told not to use telephones, the Internet or seek any other *help* except that provided by the leading teacher. Each drawing was on standard A3 paper. Evaluation criteria for both the traditional and virtual reality groups were:

- Correctness of the construction, including the relation of the plan to the section.
- Readability of the drawing, including thickness of the walls and the division between section lines and view lines.
- Proportions, which was the least important of the three criteria.

The first group received the 2D plans, photographs and a general description of the object of the task. The second group members were able to immerse themselves in the virtual object and walk around it in 3D using graphical representation engines, such as SketchUp + Enscape [13]. The evaluation was carried out without knowledge of the group of students the work was from. The grades were then statistically analysed.

FIRST EXPERIMENT (OBJECT: ROTUNDA IN STRZELNO)

The first experiment was conducted with a group of 127 students, who mostly attended the lecture on the origins of sacral Romanesque architecture in Poland. After the theoretical class, students were divided into two similar, comparable groups (group A: traditional, group B: virtual reality) and given the task of drawing the axonometric section of the former Our Virgin Lady (St Prokop's) Rotunda in Strzelno (Figure 1).

Strzelno, in central Poland, was one of the centres of the Piast monarchy, and was donated to the Norbertine nuns in the second half of the 12th Century [17][18]. Because of the rules of the order, the nuns needed to build a chapel, in which they would be separated from the common people during services. Therefore, a small rotunda church (St Prokop's Rotunda) was constructed before the Norbertines developed their monastery with a much bigger Romanesque basilica. The Norbertines left both in Strzelno. It is one of the most important Romanesque complexes in Poland.

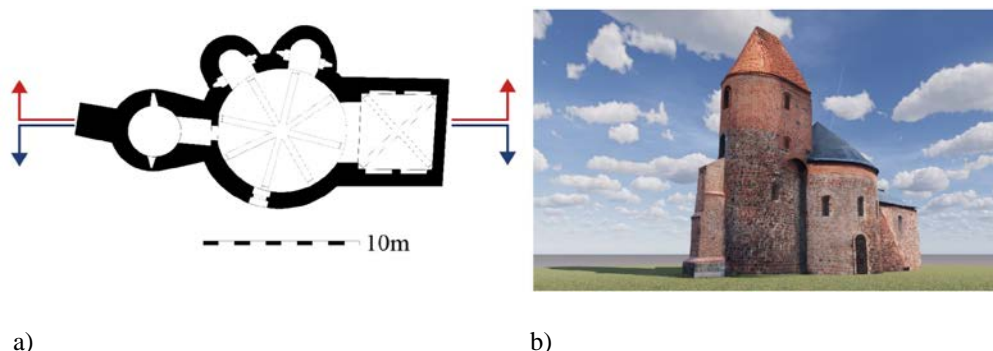a)   b)

Figure 1: a) plan of St Prokop's Rotunda in Strzelno, with marked sections: red is group A and blue is group B; b) render of St Prokop's Rotunda in Strzelno, using SketchUp + Enscape (Drawings by S. Kowalski).

RESULTS OF THE FIRST EXPERIMENT

In Poland, the grades for students are: 2 - fail; 3 - satisfactory; 4 - good; and 5 - very good. Comparing the results of the two groups (A: traditional and B: virtual reality) it was found that both achieved similar outcomes (see Figure 2).

The virtual reality group had 42 students (this was linked to the capacity of the computer laboratory), and the traditional 82. In analysing the most common mistakes, it was found that students in both groups had the biggest problem with drawing the matroneum and bifora in the temple's tower. Another common mistake was the drawing of the vault in the presbytery. Figure 4 shows the best drawing from each group.

a)   b)

Figure 2: Grade distribution for the first experiment: a) traditional group; and b) virtual reality group.

a)   b)

Figure 3: Common mistakes in the first experiment: a) traditional group; and b) virtual reality group.

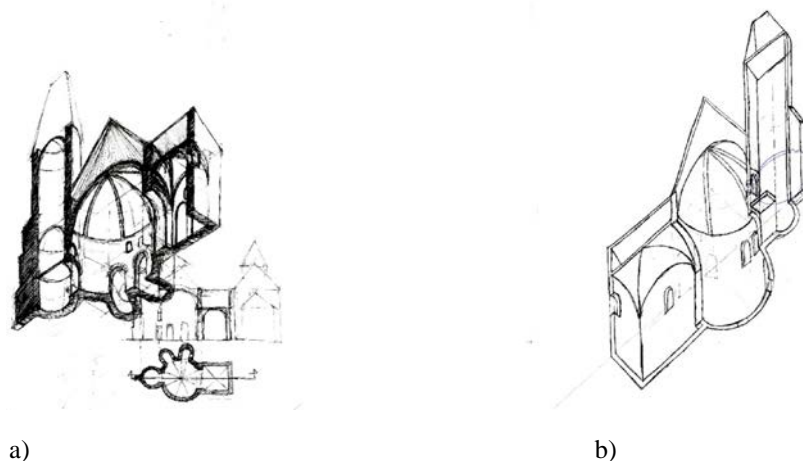a)   b)

Figure 4: Best drawings: a) best drawing from group A; and b) best drawing from group B.

SECOND EXPERIMENT (OBJECT: CATHEDRAL IN KAMIEŃ POMORSKI)

The second experiment was carried out one week after the first, reversing the student groups, which numbered 136 people in total. In this experiment, group A was the virtual reality group and group B was the traditional group. The experiment was conducted after a lecture about the development of Romanesque cathedrals in medieval Poland. Similar to the first experiment, both groups were separated from each other, so that group A drew the exercise with the help of a 3D model (49 students), and group B with traditional photographs (86 students). As before, the evaluation was carried out without knowledge of the group of students the work was from. The grades were then analysed statistically.

The Cathedral in Kamień Pomorski (Kamin) was the first brick building on the east side of the Oder River (in Poland). The construction works (east choir) started in the last two decades of the 12th Century. By the middle of the 13th Century, a transept was completed, with fixed features of the Romanesque and Gothic styles. The rest of the corpus was built in the second half of the 13th through the 14th Century [19-21]. As a result of the reformation, the cathedral retained its medieval architecture and, therefore, is the best preserved of its type in Poland.

The aim was to draw a half section and half elevation of the Cathedral in Kamień Pomorski. To focus only on Romanesque architecture, later stratifications and changes were marginalised by the teacher instructing the students not to focus on those parts. The virtual reality class received a 3D representation of the temple, with the marginalised parts coloured grey and with no texture (see Figure 5). The evaluation process was the same as before.

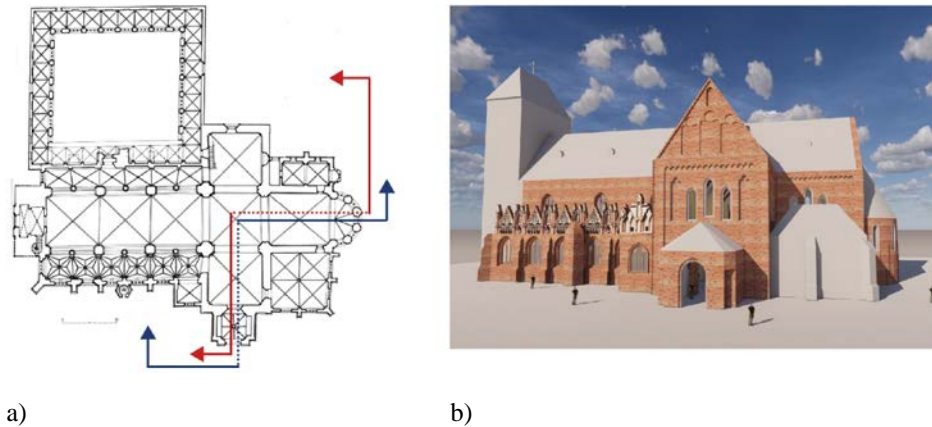a)   b)

Figure 5: a) plan of St John the Baptist Cathedral in Kamień Pomorski, with marked sections and elevations: red section: group A and blue section: group B [20]; and b) render of St John the Baptist Cathedral in Kamień Pomorski using SketchUp + Enscape, with marginalised elements in grey (Render by S. Kowalski).

RESULTS OF THE SECOND EXPERIMENT

The second experiment revealed differences between the groups favouring the virtual reality group. Though only a small gap, in general, the virtual reality group did better than the traditional group (see Figure 6). However, the 3D model was uploaded to SketchUp, which allowed the students to see elevation views of the cathedral. This shows that digital tools are preferred by the students because of their flexibility.

a)   b)

Figure 6: Grade distribution for the second experiment: a) virtual reality group; and b) traditional group.

a)   b)

Figure 7: Common mistakes in the second experiment: a) virtual reality group; and b) traditional group.

In analysing the most common mistakes, it was found that the virtual reality group made most of their mistakes constructing the chancel arch between the vaults, and the traditional group had the biggest difficulty in drawing the section through the apse (Figure 7). Shown in Figure 8 is the best drawing from each group.
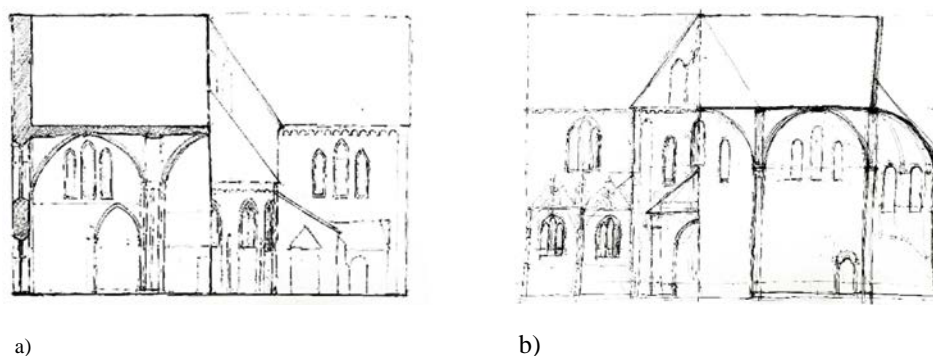

a)   b)

Figure 8: Best drawings: a) from group A; and b) from group B.

CONCLUSIONS

The experiments show that although virtual reality is thought to be an innovative technique for supporting education, virtual reality does not strongly affect the outcome of the teaching. There is no significant difference for professionals in how the information is delivered (virtual reality versus traditional), as long as it is complete. Based on the results of the research, it can be seen that the virtual reality group performed slightly better than did the traditional group. This was because of the complexity of the 3D model, and the students' ability to immerse themselves in, and walk around, the virtual object without having to leave the academic institution.

However, virtual reality has great potential to assist teaching of the history of architecture. Movement around a virtual architectural object, e.g. a castle or temple, can impart more information than do traditional photographs. The 3D tools also provide the option to create sections of any desired part of the object. This is extremely useful when explaining the complexity of an object's construction or detail.

A survey that was conducted after the classes showed that the students prefer to work on 3D models rather than photographs, which have limited perspective. Photographs lack comprehensive information by which to answer the questions that students may have when working on a *structural drawing* [14].

Furthermore, there is a risk that students will learn to find answers using 3D models rather than the *how* of finding solutions themselves by relying on their spatial imagination and general abstract manipulation. These latter skills conform to the aims of architecture and architectural education in general.

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