Virtual reality tools in teaching the conservation and history of Polish architecture

Szymon Kowalski, Piotr Samól & Robert Hirsch

Gdańsk University of Technology
Gdańsk, Poland

ABSTRACT: Virtual reality and its impact on teaching conservation and architectural history is the subject of this article. During the COVID-19 crisis in 2020, the education of students of architecture was transferred by Gdańsk University of Technology (GUT), Gdańsk, Poland, to distance learning. This method has provided academics an opportunity to examine the impact of virtual reality and remote education on architectural history and conservation. The outcome of that examination - not of graphical skills typical of architecture - but rather of spatial imagination in a three-dimensional environment is presented and discussed in this article.

INTRODUCTION

The theory of conservation is a complicated part of architecture studies, due to its many aspects and approaches to architectural heritage. With the help of modern virtual reality tools, teachers can explain, with a 3D model, all of the concepts of conservation theory, as support to the traditional lectures that include plans, sections, drafts and photographs.

After a series of lectures that lasted the entire semester covering the general topic of the theory of conservation and contemporary architectural issues, students (circa 180) were divided into two groups. The first group prepared 2D materials, including maps and photographs showing transformations of the Castle of the Teutonic Order in Malbork, Poland, from the 13th Century until the present day. The second group received 3D models of the castle for the same historical period. To measure the impact of the 3D models, both groups were asked to fill in a questionnaire covering the conservation carried out on the castle. Other questions concerned the possible regeneration of the damaged castle.

The courses covering history and conservation in the Faculty of Architecture at Gdańsk University of Technology (FA-GUT) include monuments and cultural heritage. Because of the increasing number of foreign students in Poland, their knowledge about the local culture is crucial. Therefore, the authors of this article have compared two groups of students who had to analyse, at different stages of their education, the architecture of the medieval castle in Malbork.

The first group consisted of 142 students from the History of Polish Architecture course (fourth term, BA degree). The second was a group of 21 international students who attended the Theory of Conservation course (first term, MA degree). This study was applied to the analysis of the findings on using virtual reality (VR) in historical education.

The main aim of the course, History of Polish Architecture I, is to gain an *understanding [of] the history of Polish medieval architecture* [1]. Students develop abilities in drawing and spatial analysis alongside the history of architectural objects. Besides spatial imagining skills students also will learn to:

- determine the basic pre-Romanesque, Romanesque and Gothic architectural objects and their spatial arrangement;
- describe architectural objects through terms specific to medieval architecture (e.g. gallery, collegiate church palatium);
- describe the schematic functional solutions of secular and religious construction from the Middle Ages;
- know the Romanic and Gothic architectural detail (including portals, peaks and vaults).

The application of virtual reality for architecture students has been described in a previous article [2]. Consideration of drawing ability was not part of this work [3-5]. The focus here was on the knowledge addressed through the questionnaire. The main topic from the students' education considered here was *medieval castles,* which is one of the obligatory topics [1].

The progressive education of students should adopt and implement new technologies. Virtual technology is one of the new tools applied in education, creating a more student-friendly immersive environment [6-8].

As a result of the global COVID-19 crisis, students of the Faculty of Architecture used remote studies to prevent the spread of coronavirus. Students gained access to *e-Nauczanie,* the e-learning platform at the GUT. The whole of the History of Polish Architecture has been transferred to this platform. Teachers prepared a set of lectures covering topics from the *architecture of Cistercians Order* to *medieval wooden architecture*, in total 15 topics. One of the topics covered was *medieval castles*, which focuses on the Castle of the Teutonic Order in Malbork.

THE OBJECT: MALBORK CASTLE

The castle of Malbork is included in the UNESCO World Heritage List. It is the subject of classes in the courses of architectural history and the theory of conservation. The oldest part of the castle was designed in the 1270s as the border-land fortress of the local commander of the Teutonic Knights. However, the conquest of Pomerania at the beginning of the 14th Century, and the political decision to remove the Seat of Grand Master of the Order from Venice (Italy) to Malbork/Marienburg (then in Prussia), caused great development of the castle.

In the following century, the castle received two baileys (residential for the Grand Master, and commercial) and was integrated with the local municipality (city of Malbork). Consequently, before 1457, the Teutonic Knights created one of the largest fortified complexes in Europe, which became the symbol of Gothic brick architecture in northern Europe. Their defeat in the Thirteen Years' War (1454-1466) meant that Malbork was taken by Polish kings, and thus lost its capital status, but remained the economical centre of the wealthy Werder/Żuławy region. During the Swedish wars in the 17th Century, the High Castle was donated to the Jesuits. After the first partition of Poland (1772), Malbork was occupied by the Kingdom of Prussia.

The era of absolutism, rationalism and industrial revolution bore great risks for the castle because Prussian authorities planned to sell it as a reservoir of bricks. Fortunately, German architects (Gilly and Schinkel) stopped this attempt at devastation. For the next two centuries, Malbork became a laboratory for almost all conservation theories (romantic, stylistic, puristic and modern). Conrad Steinbrecht rebuilt the castle (1890s-1920s) based on the principles of stylistic restoration. The huge destruction caused by WW2 meant that after the war Polish conservators could again continue their work in conformity with the current theories [9-11].

Nowadays, Malbork is a great example of a medieval castle, famous for a gargantuan scale as a capital of the Teutonic Order Knights. What is more, Malbork is an important example of conservation techniques and, as a heritage monument, is compared to the works of Eugène Viollet-le-Duc in Carcassonne, France.

METHODOLOGY

The resources were prepared and uploaded to the e-Nauczanie platform for student access. Students were instructed on how to prepare for the exercise, which was an evaluation of knowledge gained from the following resources:

- Lecture in a pdf file covering medieval castles.
- Support lecture in a pdf file covering specific details of medieval castles.
- Scans of the book: *Leksykon zamków w Polsce* by Leszek Kajzer, Stanisław Kołodziejski and Jan Salm, pages 9-58 focusing on medieval castles [12].
- Video lecture about the Malbork castle.
- A 3D model of the Malbork castle, including a virtual fly around.

EXERCISE

Before attempting the exercise, students had to read both lectures and extra materials, watch the video lecture [13] of the Malbork castle (which covered the history and conservation) and, finally, become familiar with the 3D model [14].

The exercise was an on-line test with six questions, time limited to 24 minutes, and with only one attempt allowed to answer each question. The questions were generated so that every student received a different set of questions; this was to prevent communication between students. Based on the lecture, questions were on different parts of the castle, such as the bergfried (tall tower), dansker (toilet facility), dry moat and three levels of the castle layout (Figure 1).

A map of the castle was attached to the following example question:

You can see the plan of the castle in Malbork from the beginning of the 17th Century. There are marked nine medieval objects. Please match the numbers to the objects.

The correct answers for this set of questions are: 1 → the Middle Castle; 2 → the High Castle; 3 → the parish church of St John; 4 → the old town of Malbork; 5 → the Lower Castle; 6 → the Palace of Grand Masters (1380–1410); 7 → the wall of Heinrich von Plauen (after 1410); 8 → a lavatory (dansker) and 9 → the Bridge Gate.

The points awarded were appropriate to the difficulty of the question. For this set of questions points were:

Q1 - 2 points; Q2 - 1 point; Q3 - 2 points; Q4 - 1 point; Q5 - 3 points; Q6 - 1 point.

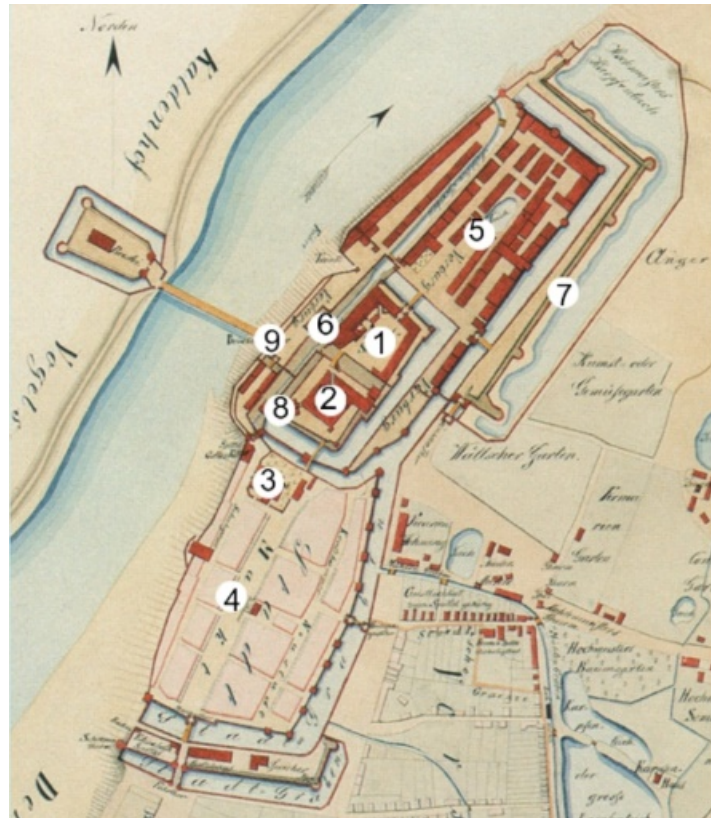The highest possible score was 10 and the pass rate was six.

Figure 1: Map of the castle in Malbork from the beginning of the 17th Century.

RESULTS OF THE EXERCISE

The test was carried out on the two groups of students as described above. The first, from the History of Polish Architecture course - group A - were native Polish speakers. The second, from the Theory of Conservation course - group B - was composed of international students from a course taught in English.

The Malbork castle is a remarkable piece of castle architecture, as well as an extremely important object in terms of conservation. Both need to be covered to fully understand the key issues of the Malbork castle.

Group A had 142 students: 84 (56% of the total) achieved an excellent grade (9.5-10.0). Ten students did not receive a grade and the rest of the students scored good or very good marks. The average grade of the group was 9.1. The results (Figure 2) show the peak of the curve on the far right, which shows the success of the students.
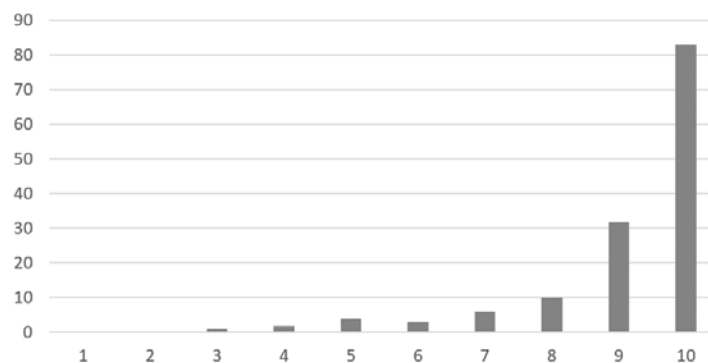

Figure 2: Grade distribution for group A - using virtual reality tools.

Group B had 21 students. Four students achieved the highest mark (9.5-10.0); eight achieved the next highest (9.0-9.5). Four students, which represented 19% of the group, failed the test. The average grade for the group was 8.36 (Figure 3).
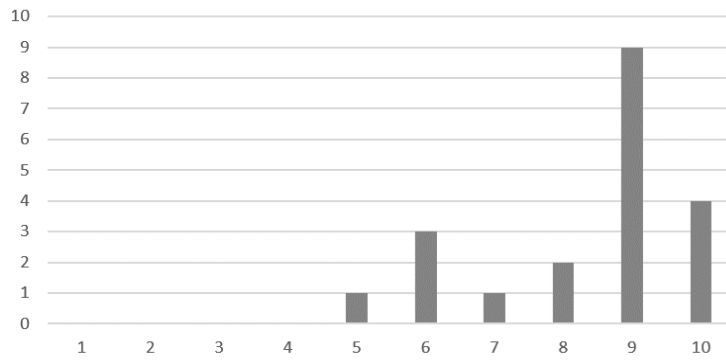
Figure 3: Grade distribution for group B - using virtual reality tools.

Comparing the two outcomes of the exercise, both groups did extremely well with the use of the virtual reality Malbork castle. The History of Polish Architecture group A did better than the Theory of Conservation group B; 56% of group A received a maximum grade as against 19% of group B.

COMPARISON EXERCISE

Two more quiz-based exercises were completed by the students and prepared by the same teacher as the Malbork castle quiz. The materials delivered to the students were similar to the previous exercise on *medieval castles,* including the literature and video lecture. The results curve is more *balanced* and typical of a Gaussian distribution rather than that for the exercise above, in which virtual reality was used (Figure 4 and Figure 5). All the quizzes were prepared by the same lecturer, to decrease any systematic bias.
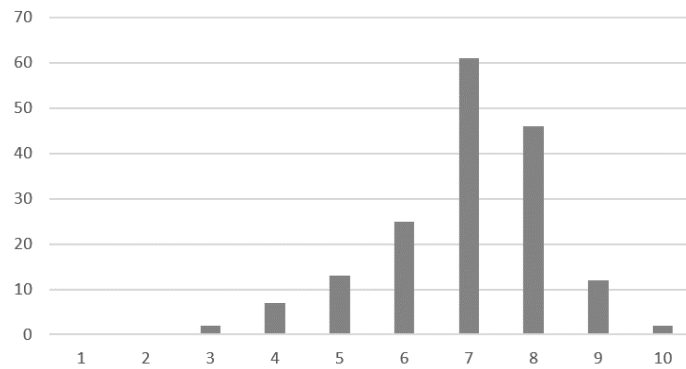
Figure 4: Grade distribution for the quiz, *Transition style between Romanesque and Gothic* - without virtual reality tools.
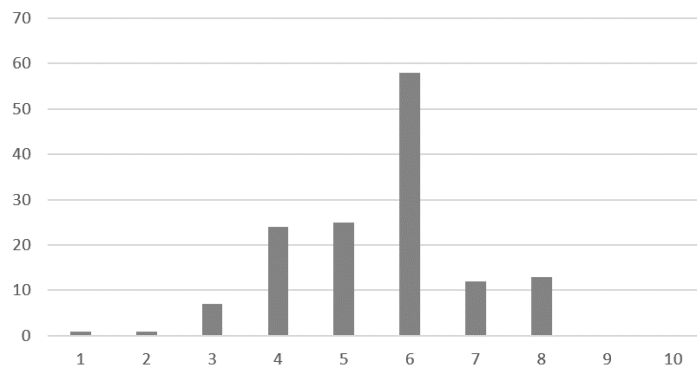
Figure 5: Grade distribution for the quiz, *Gothic construction systems* – without virtual reality tools.

DISCUSSION

- 3D model as a support.

The most important conclusion is that the 3D model can act as support rather than be the main element of the education. Most important in the education is a lecture covering all the problems, transformations, destructions, and so on, of the castle. With knowledge transferred via lecture, which itself is based on many years of research, the 3D model can

provide a comprehensive image of the studied object. Furthermore, the 3D model, without proper commentary or a lecture will not advise the student of the nature of the problem or the transformations of the object.

- Sightseeing objects without the need to travel.

In a time of global quarantine, the use of virtual reality and 3D models provides a great opportunity to learn about objects that are far away and out-of-reach. Of course, this is a superficial way of learning the history of architecture. Nothing will substitute for accessing the original, but still it may be helpful in acquiring a large amount of knowledge. This is especially so, if there is global quarantine and prohibited access to monuments and objects.

- Learning effectiveness.

The use of 3D models and virtual reality can improve the learning of students [8]. Lectures based on photographs and technical drawings sometimes cover a small part of the lecture, such as the dansker, St Mary figure or elements of the defence system. With immersive 3D models students can relate to every part of the castle, creating a complete vision of the whole castle. This complete vision can be obtained without a physical visit to Malbork. Obviously, a real visit would produce a greater understanding of the medieval fortress concept. However, the History of Polish Architecture and the Theory of Conservation, can be taught remotely.

- The valuation of architectural heritage by multicultural student groups.

In the quiz exercise between two virtual reality groups (Figure 2 and Figure 3), international group B did slightly worse than did group A, which consisted mainly of Polish students. A reason for this is that the Malbork castle is one of the most important places of heritage in Poland, which means most of the Polish students knew the topic in general and some of the students had been there [15].

- Lack of graphical expression.

Unlike many of the traditional History of Polish Architecture course exercises, this was an on-line multi-answer test. It excluded a graphical representation and drawings [3-5] and was restricted to knowledge gained through the lectures and literature. However, focusing on the grades obtained, it seems that most of the knowledge was well received.

- The model and learning by immersion.

The greater advantage of the 3D model over photographs and technical drawings is the possibility to walk or *fly* around objects. This produces the same effect as for a physical model, with the possibility to rotate objects and view a part or whole of the object. During in class lectures, a paper model is shown to students to help them memorise the architectural object and locate themselves spatially.

- Things that are not certain.

The virtual tour around the Malbork castle can include parts that are not extant (from history or the future); photographs cannot cover the object in this sense.

SUMMARY AND CONCLUSIONS

The use of virtual reality can affect positively knowledge transfer and education in the History of Polish Architecture and Theory of Conservation courses. This is a tool with great potential for remote learning of a complicated topic, such as architecture. Mainly this is by coping with abstract drawings and spatial imagination. However, 3D models and immersive environments cannot be effective by themselves, because the engineering student will need a proper background in theory, provided by lectures and literature sources, to recognise and understand the material. Hence, virtual reality tools are a support resource for education.

A 3D model can be programmed to explain, step-by-step, the research of objects, in a way similar to a *typical* lecture. The authors would like to research fully immersive and interactional issues in following articles.

REFERENCES

1. Course Chart for History of Polish Architecture I. Karta Przedmiotu dla Kursu Historia Architektury Polskiej I, A:01648 (2019/2020).
2. Kowalski, S., Samól, P., Szczepański, J. and Dłubakowski, W., Teaching architectural history through virtual reality. *World Trans. on Engng. and Technol. Educ.,* 18, **2**, 197-202 (2020).
3. Sołtysik, M.J., Developing students' spatial skills and teaching history of architecture through *structural drawing*. *World Trans. on Engng. and Technol. Educ.,* 18, **1**, 12-17 (2020).
4. Białkiewicz, A., Education of architects: historical and contemporary aspects of teaching freehand drawing. *World Trans. on Engng. and Technol. Educ.,* 17, **1**, 17-22 (2019).

5. Żychowska, M.J., Teaching drawing to a new generation of engineers architects. *World Trans. on Engng. and Technol. Educ.,* 17, **1**, 60-65 (2019).

6. Gębczyńska-Janowicz, A., Virtual reality technology in architectural education. *World Trans. on Engng. and Technol. Educ.,* 18, **1**, 24-28 (2020).

7. Cook, M., Lischer-Katz, Z., Hall, N., Hardesty, J., Johnson, J., McDonald, R. and Carlisle, T., Challenges and strategies for educational virtual reality. *Infor. Technol. and Libraries*, 38, **4**, 25-48 (2019).

8. Lebiedź, J. and Szwoch, M., Virtual sightseeing in immersive 3d visualization lab. *Proc. of the Federated Conf. on Computer Science and Infor. Systems. 4th Conf. on Multimedia, Interaction, Design, and Innovation*, Gdańsk 2016, Annals of Computer Science and Information Systems, 8, 1641-1645 (2016).

9. Kilarski, M., Odbudowa i Konserwacja Zespołu Zamkowego w Malborku w Latach 1945-2000, Malbork (2007) (in Polish).

10. Pospieszny, K., *Domus Malbork. Zamek Krzyżacki w Typie Regularnym*. Toruń: Wydawnictwo Naukowe UMK (2014) (in Polish).

11. Bukal, G., Konserwacja zamku w Malborku jako przykład kształtowania się doktryny konserwatorskiej. *Ochrona Zabytków*, 56, **3** (242), 91-102 (2008) (in Polish).

12. Kajzer, L., Kołodziejski, S. and Salm, J., *Leksykon Zamków w Polsce.* Arkady (2001) (in Polish).

13. Hertzog, P.E., Effective use of video lectures for design project students. *World Trans. on Engng. and Technol. Educ.,* 17, **2**, 181-186 (2019).

14. Pielak, D., Kowalski, M. and Lebiedź, J., 3D model preparing patterns for interactive urban visualization. *TASKQuarterly: Scientific Bulletin of Academic Computer Centre in Gdańsk*, 22, **4**, 341-349 (2018).

15. Szczepański, J., Valuation of architectural heritage by multicultural student groups. *Global J. of Engng. Educ.*, 21, **3**, 196-201 (2019).