EXTENDING COMPUTER GRAPHICS CURRICULUM BY CULTURAL HERITAGE-RELATED ASPECTS - SILK ROAD ARTIFACTS CASE STUDY

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Abstract

Teaching of computer graphic (CG) courses involves creation and processing of graphical content by students. While the main goal of using specific content is to well present aspects of specific topics and techniques, it is a proven fact that students are more interested in doing projects that operate on interesting and potentially useful content.

The preservation and dissemination of cultural heritage involves more and more aspects from the computer graphics area. That relates especially to 3D scanning, processing and presenting various cultural heritage artifacts, which has especially grown in importance in the current pandemic time as the safe alternative to visiting museums or heritage sites. While 3D digitizing of heritage objects is rather a specific utilization of computer graphics, it involves in majority typical techniques that are commonly used in different CG fields.

The CG course is regularly taught during the 4th semester of the 1st degree Computer Science studies at Lublin University of Technology. We are describing an attempt to include cultural heritage related aspects into standard CG teaching in order to improve students' interest in the course and at the same time encourage their involvement into exploring and preserving cultural heritage. The Silk Road heritage was chosen as the source of materials for the modified course thanks to the long-term cooperation with Samarkand (Uzbekistan) museums, and ongoing digitization activities.

A research question has been set: Whether a synergy of acquired skills can be obtained by extending the standard computer graphics course by the basics of cultural heritage models processing, without harming the main goal of the course. The discussion about students' projects effects and grades acquired in comparison to the former editions of the course is presented. In our opinion providing examples of real-life artifacts models not only gave students the opportunity to be involved in the professional applications of CG and acquire experience useful during the heritage digitization, but also improved their engagement during the classes.

Keywords: Computer graphics teaching, cultural heritage, Silk Road, 3D models processing.

1 INTRODUCTION

Teaching of computer graphic (CG) courses involves creation and processing of graphical content by students. While the main goal of using specific content is to well present aspects of specific topics and techniques, it is a proven fact that students are more interested in doing projects that operate on interesting and potentially useful content.

The Computer Graphics Basics course is being taught at the first level of Computer Science studies at Lublin University of Technology. It uses a standard layout - lecture and practice classes. The course program introduces students to the basics of computer graphics processing, starting from raster graphics, through vector graphics and then 3D graphics. The aim of the course is to familiarize students with the basic techniques of graphics processing used in typical tasks of creating contemporary applications and their interfaces. The broad range of computer graphics knowledge covered by the course requires from students involvement in the implementation works in various areas of computer graphics (raster graphics, vector graphics, 3D, animation). During the course hours, students receive theoretical knowledge and practice basic techniques useful in carrying out such tasks. Works from a given area (assigned individually) are performed by themselves. In the case of some of them, this is sometimes an incentive to independently search for more advanced solutions to the problems encountered than those practiced in class. In the previous years, the obtained independent tasks were not related to each other and the topics were chosen randomly, which made some students negotiate a change of topic.

In order to obtain greater involvement of students in the progress of the course, it was decided to introduce a uniform topic of assigned tasks. So that the implementation of subsequent tasks leads to the overall end result. After searching for available topics that could interest students, it was decided to make use of the involvement of the Department of Computer Science in 3D scanning of cultural heritage objects from, among others, the area of the former Silk Road [1]. Ongoing modifications of the computer graphics course are in line with a bigger trend at LUT. Teams of interdisciplinary researchers throughout the university investigate modern trends in the field of didactics like professionalization and remote teaching, to mention the following works [2, 3, 4, 5, 6, 7, 8].

The 3D scanning, processing and presenting of various cultural heritage artifacts involves aspects from the computer graphics area related to vector and 3D graphics (meshing of scanned objects) as well as raster graphics (creating and adjusting of texture materials). While 3D digitizing of heritage objects is rather a specific utilization of computer graphics, it involves in majority typical techniques that are commonly used in different CG fields [9].

Courses implementing the teaching of computer graphics for cultural heritage purposes are already conducted [10, 11], and from the analysis of their curriculum it can also be concluded that they cover aspects taught in the standard CG course. Thus cultural heritage related examples can be used in basic course teaching. It is also an advantage that the course is supplemented with aspects of preservation and dissemination of cultural heritage, especially in virtual media. That field of cultural heritage has especially grown in importance in the current pandemic time as the safe alternative to visiting museums or heritage sites.

Considering the above we would like to pose the following research question:

Whether a synergy of acquired skills can be obtained by extending the standard computer graphics course by the basics of cultural heritage models processing, without harming the main goal of the course.

In order to answer the research question, we introduce methods and tools used for teaching standard and modified computer graphics course. The discussion about students' projects effects and grades acquired in comparison to the former editions of the course is presented as well.

2 METHODOLOGY

In this chapter we introduce methodology aspects, like organization of the didactic process during the computer graphics course, and using heritage-related resources obtained as a result of cooperation with the Silk Road museums. Finally, techniques of estimating effects of the course modifications are described.

2.1 Methods and tool used for CG teaching

Students attending the computer graphics course acquire competences using 3 methods: theoretical knowledge is passed on during the lecture; during the laboratory classes, typical techniques of graphics processing are practiced; the application of acquired knowledge and skills is verified by the implementation of individual design tasks including 2D and then 3D graphics. The assessment of the implementation of tasks is performed in terms of the selection and ability to use graphic techniques, artistic values are taken into account to a small extent so as not to disturb the assessment of acquired competences.

In the standard edition of the course, design tasks for a specific student are usually not related to each other, so the student carries out 2 or 3 different projects covering individual stages of learning: 2D graphics processing, modelling of 3D objects, animations.

2.2 Modifications involving computer heritage content

In the course edition taking into account the use of cultural heritage objects, it was decided to propose a series of tasks related to a specific object for implementation by one student. This sequence included working with texture images, modifying the mesh of the scanned object, and finally modelling the scene and animating the object. The aim of the work was to prepare a virtual exposition presenting a 3D model of a cultural heritage artifact. Students were provided with the base models acquired during 3D scanning in the Afrasiab Museum of Samarkand [12] and Scientific-Experimental Museum-Laboratory of the Samarkand State University in Uzbekistan [13].

Figure 1 shows examples of 3D base scans along with the effects of arranging scenes with their enhanced models participation. The models substituted materials for exercises used so far, but the sequence of independent tasks that the students had been carrying out remained the same. Also the method of evaluation has been the same as in the previous years - assessment of the correctness of the techniques used and the quality of the obtained effect. For students, the difference was mainly in setting the common goal for the performance of individual tasks - additional motivation to properly complete the task, the effect of which will be needed in the next stages.

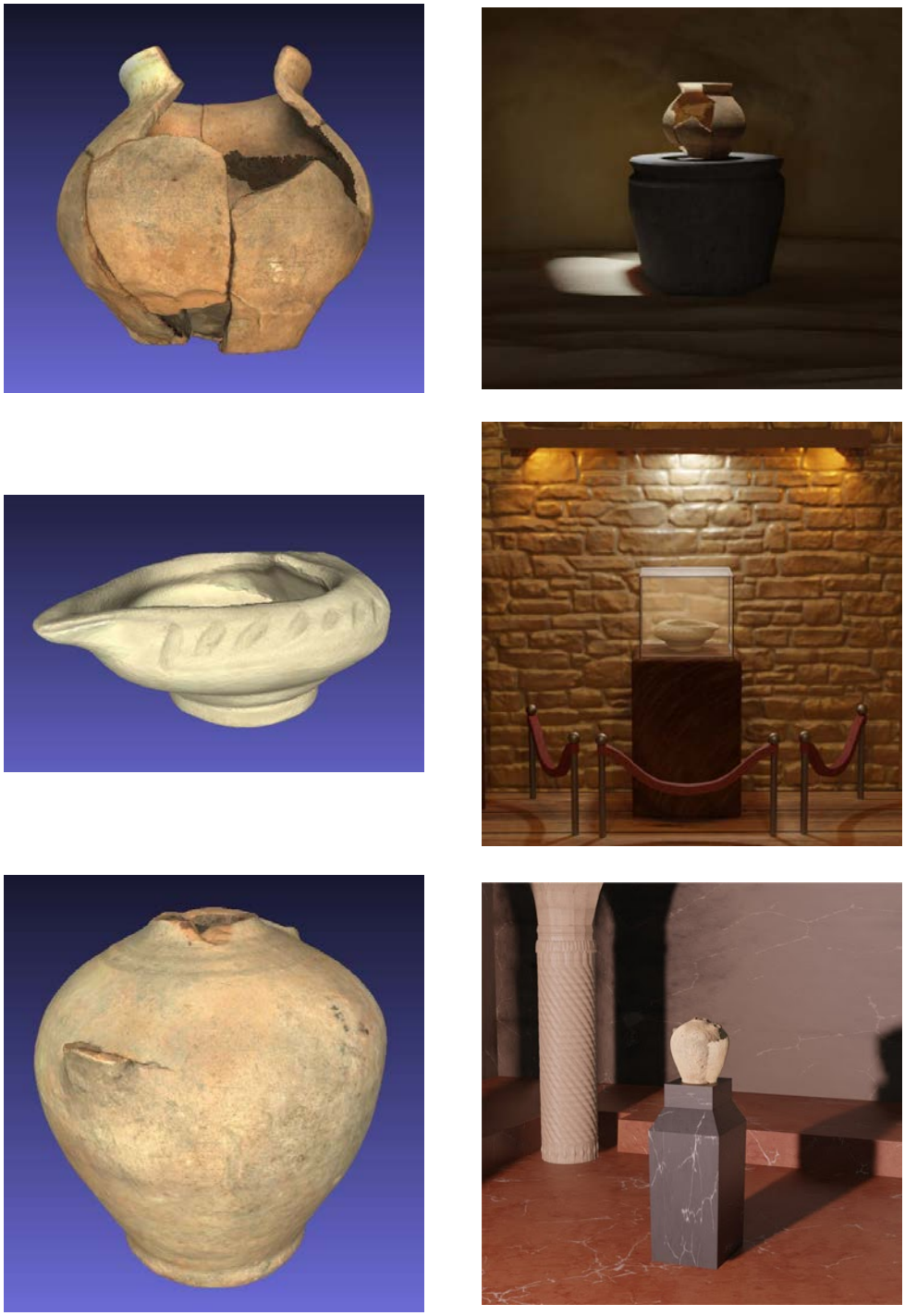

Fig. 1. Sample 3D models of scanned cultural heritage objects, used by students (left) along with the effects of arranging scenes with their participation (right).

2.3 Techniques for estimating effects

In order to check whether there is an effect on students' grades caused by extending the standard computer graphics course by the basics of cultural heritage models processing, we have analysed students' achievements in the years 2018-2020. During these years the knowledge verification methods were comparable, i.e. students worked on individual assignments, with the advisory role of a teacher. During 2018 and 2019 the classes were conducted in the stationary form (in a classroom), in 2020 in the remote form. The lecture was conducted by the same person, although the laboratory classes were conducted by 6 different teachers.

The attendees of extramural studies were not included due to the significant differences in their background negatively influencing comparability, being the computer graphics course half shorter. The data we were able to obtain was anonymized, and did not contain demographics data like sex, etc.

We have analysed the final course grades, which were computed by the virtual dean's office software in the following way - average value of a grade from the laboratory classes and a grade from the lecture, rounded to 0.5 precision. In our opinion such a grade shows the best general level of students' knowledge in computer graphics. Each student is granted 3 attempts to pass the course. The next attempt is granted only after receiving a negative grade in the current one. The final grades show the final results of students being able, or not, to pass the course. They are in the same number as in the case of the 1st attempt, although they might differ in values in the way that a student who got 2.0 might have improved in subsequent attempts.

We have decided to perform a statistical test in order to help answer the research question. In case of analysed grades do not follow the normal distribution according to the Shapiro-Wilk normality test, we agreed to perform Wilcoxon rank sum. The significance level was assumed to be 0.05. Computations were performed in R environment [14].

3 RESULTS

For the purpose of this paper, we have analysed grades of 367 undergraduate students of Computer Science at LUT who attended the computer graphics course in 2018-2019, and another 206 students who attended the course in 2020. The attendees of extramural studies were not included in the analysis.

The summary of the final computer graphics course grades is presented in Table 1. By "Before CH" we mean the course grades before introducing cultural heritage aspects to the classes, by "After CH" we mean the grades after introducing these aspects. The following abbreviations were used as well: "No" (number of grades), "%" (percentage of particular grades), "AVG" (arithmetic average), "SD" (standard deviation). Histograms are presented in Figure 2, and box plots in Figure 3.

Table 1. Summary of the students' course grades in 2018-2020

			Grades						***AVG***	***SD***
Year			***2.0***	***3.0***	***3.5***	***4.0***	***4.5***	***5.0***		
2018-2019	**Before CH**	**No**	**21**	**42**	**74**	**24**	**133**	**73**	4.05	0.83
		%	6%	11%	20%	7%	36%	20%	-	-
2020	**After CH**	**No**	**7**	**20**	**67**	**8**	**38**	**66**	4.09	0.82
		%	3%	10%	33%	4%	18%	32%	-	-

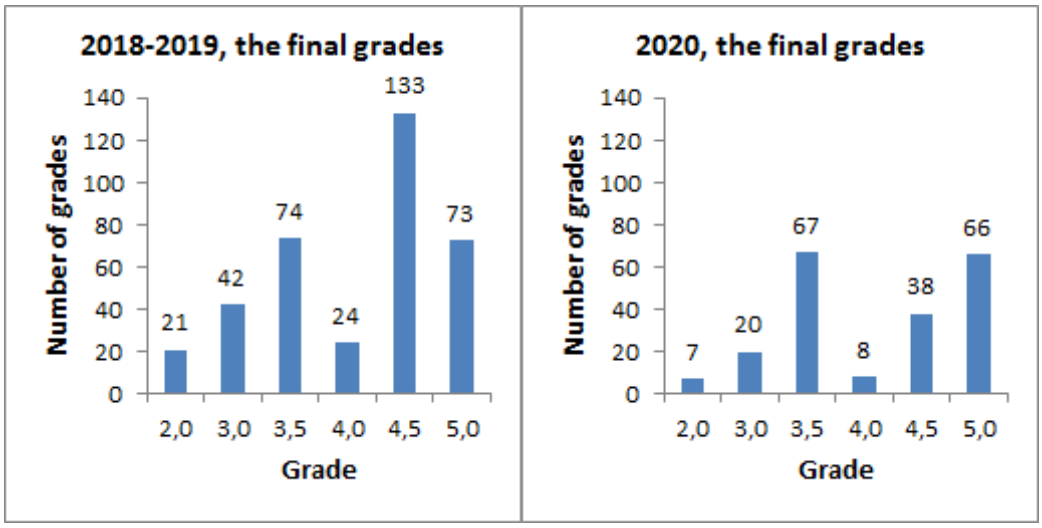

Fig. 2. Histograms of students' course grades before (2018-2019) and after (2020) introducing cultural heritage aspects to the classes

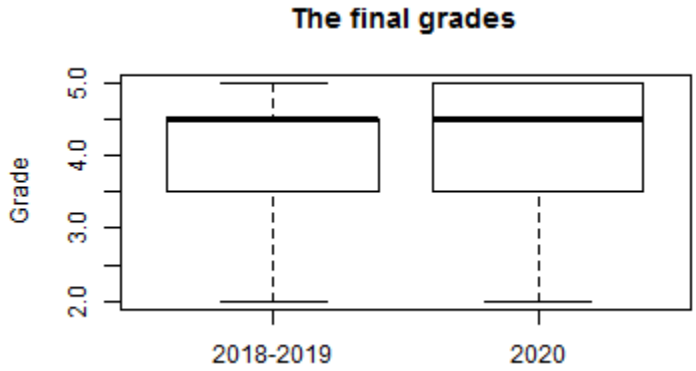

Fig. 3. Box plots showing the distribution of students' course grades before (2018-2019) and after (2020) introducing cultural heritage aspects to the classes

Two vectors of data were constructed - (1) the final grades in 2018-2019 before introducing cultural heritage aspects to the classes, and (2) the final grades in 2020 after introducing these aspects. Both vectors did not follow the normal distribution, which was revealed by the Shapiro-Wilk normality test - each time p-value<0.001. Thus the Wilcoxon rank sum test was performed. No statistically significant difference between grades in vector (1) and (2) was revealed (two-tailed test; p-value=0.43; H1: grades in 2020 are different than in 2018-2019). The significance level was set to 0.05.

According to the statistical tests, the grades scored by students attending the computer graphics course were not statistically significantly affected by introducing cultural heritage aspects to the classes. We could even say that, after looking at raw data and percentage of 5.0, a small shift towards higher grades occurred. Nevertheless, it is statistically insignificant. This slight improvement might be caused by higher motivation of students either influenced by the remote teaching in some unknown manner.

4 CONCLUSIONS

The introduction of tasks related to the protection of cultural heritage to the course of the basics of computer graphics allowed students to become acquainted with this increasingly developing aspect of the use of computer graphics techniques. Students could experience the actual implementation of the learned knowledge in support of an exemplary field, not directly related to IT.

The main purpose of this article, however, was to answer the question whether such modification of the course does not have a negative impact on its main goal - learning the basics of computer graphics. The statistical analysis of the grades obtained by students in the previous editions (2018-

2019) and in the pilot edition (2020) using the described change showed no significant difference between these periods, which indicates that the change did not have a negative impact on the computer graphics skills acquired by students. There was also a slight increase in the number of maximum grades, which could potentially be explained by the greater involvement of students in the implementation of an interesting project. However, confirming this hypothesis would require further research.

During the pilot course the classes were transferred online, which was related to the introduction of regulations preventing the spread of the Covid-19 pandemic. According to the authors, the change did not have a significant impact on the course implementation and the grades obtained. This is due to the fact that the previous course has focused on the independent implementation of project tasks by students, with the advisory role of a teacher. The laboratory classes served only the purpose of introducing the basic techniques and consulting the progress of work - which was successfully transferred into online communication.

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