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INTRODUCTION OF PEER EVALUATION IN THE STUDY OF COMPUTER GRAPHICS - OBSERVATIONS ON THE POSSIBILITY OF INVOLVING STUDENTS IN THE EVALUATION PROCESS OF 3D VISUALISATIONS

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Abstract: *This study examines the impact of incorporating ICT-enhanced peer evaluation throughout the course of 3D modelling, including midterm and final assessments. Rubrics for peer evaluation were developed to ensure structured and consistent assessment of student work, focusing on criteria such as clarity, objectivity, feedback and overall effectiveness. The practical component involved designing peer assessment forms, implementing these assessments in the classroom and comparing teacher and student assessments. As part of the study, students were required to create 10 landscape-themed visualizations using various 3D modeling techniques, textures, and rendering strategies. Assessments were conducted mid-semester and at the end of the course, with students evaluating their peers on communication, modeling, texturing, and stylistic coherence. The results suggest that clearly defined criteria and motivational strategies are essential for successful peer assessment. It was found that students tended to evaluate their peers more leniently than teachers, indicating a possible bias in peer assessment. Effective implementation requires continued engagement and input from educational experts to optimize the assessment categories and ensure meaningful peer feedback.*

Key words: ICT-assisted peer evaluation, study of 3D computer graphic, qualitative analysis, quantitative marks

1. INTRODUCTION

Peer-to-peer evaluation, also known as peer assessment, is an educational approach in which students evaluate each other's work based on predefined criteria. This method has gained prominence in recent years as a means of improving student learning outcomes, promoting critical thinking and encouraging active engagement in the educational process (Topping, 1998). The theoretical foundations of peer evaluation are rooted in constructivist theories of learning, which assume that learners construct their knowledge through active participation and social interaction (Vygotsky, 1978). One of the main benefits of peer evaluation is its potential to deepen learners' understanding of the subject matter. By participating in the evaluation process, students must use their critical thinking skills to analyze and provide feedback on the work of their peers. This process not only strengthens their own knowledge, but also familiarizes them with different perspectives and interpretations of the same material. Studies have shown that students often learn as much from evaluating others as they do from evaluating themselves (Falchikov & Goldfinch, 2000). This reciprocal learning process is an effective tool for improving the cognitive and metacognitive skills that are essential for academic success. Peer assessment also encourages students' independence and sense of responsibility. When students take on the role of assessor, they are more willing to take responsibility for their learning. This greater responsibility can lead to higher motivation and engagement, as students are aware that their contributions have a direct impact on the learning experiences of their peers. In addition, the process of constructive feedback helps students to develop important interpersonal skills such as communication, empathy and the ability to give and receive criticism in a constructive manner (Nicol, Thomson & Breslin, 2014). Another significant benefit of peer evaluation is its ability to improve formative assessment in educational settings. Traditional assessment methods, such as exams and standardized tests, often provide limited feedback and do not necessarily promote deep learning. In contrast, peer evaluation allows for continuous, formative feedback that can accompany students throughout the learning process. This continuous feedback loop helps students identify areas for improvement and refine their understanding prior to final assessment (Hattie & Timperley, 2007). In addition, peer assessment can contribute to the development of self-assessment skills that are critical for lifelong learning. By being assessed by their peers, students become more familiar with assessment criteria

and quality standards. This familiarity enables them to apply these standards to their own work, improving their ability to self-assess and regulate their learning (Andrade & Valtcheva, 2009). Despite its many advantages, peer review is not without challenges. Issues such as bias, lack of reliability and students' discomfort in assessing their peers can hinder its effectiveness. However, these challenges can be mitigated through structured training, clear guidelines and the use of technology to facilitate anonymous assessments (Sluijsmans, Dochy & Moerkerke, 1999). In summary, peer-to-peer evaluation is a valuable pedagogical tool that enhances learning by promoting critical thinking, student autonomy, and self-assessment skills. Its effective implementation can transform the learning experience, making it more interactive and student-centered. Future research should focus on the development of best practices and technological solutions to overcome the challenges associated with peer evaluation and ensure its effectiveness and acceptability in different educational contexts. With the goal of making the class more interactive to evaluate and comment on the partial and final results of student projects in the Basics of 3D Modeling course, we introduced analytical and holistic assessment rubrics and asked students for their opinions on the implementation of the assessment. Thus, the focus of the study was to test the appropriateness of the implemented evaluation method in Computer Graphics, to evaluate the process of deriving such assessment lessons, and to gather opinions on the motivation for the continued use of peer evaluation during the pedagogical lessons of the course.

2. METHODS

The experimental part of the study included the preparation of peer assessment forms, the preparation of a lesson using this type of assessment method, the implementation of an assessment lesson, the evaluation of the assessments received from the teachers of the lesson and from the students, the comparison of the results and a critical evaluation of the sense of introducing peer assessment and the determination of directions for future study lessons. The objectives of the study work in the subject were to create 10 visualizations on the topic of landscape, which included different levels of detail of the models. The work therefore included 3D modelling and visualisation using simple and more complex modelling techniques, texturing, determining materials, placing lights and cameras, and determining the optimal settings for use. Assessment surveys (MS Forms, Moodle workshop) were created for the mid-semester products, when students submitted concepts, ideas, references and designs, and for the final products. The peer evaluation of the interim results took place in March 2024, the final products at the end of May 2024. In the evaluation both at the beginning of the work and at the end, students had to evaluate their fellow students from the point of view of comprehensive communication of the topic, i.e. whether the student clearly presented the goals and purpose of the work, they also evaluated the modelling and texturing, lighting and camera techniques used and what style their fellow students achieve and the level of visualization.
60 students from the Basics of 3D Modelling course participated in the peer assessment, but this number decreased during the assessment process.
Both analytical and holistic rubrics were used in the assessment. The analytical rubric is structured in detail and includes separate evaluation criteria. Each criterion is divided into several performance levels. The holistic rubric considers the entire product, without breaking it down into individual criteria.
Analytical rubrics with grades from 1 to 4 were defined for specific visualization features in terms of geometry, textures, lighting, stylization and degree of visualization: Holistic rubrics finally evaluated the product visualization as a whole with a single grade. The grades were then converted into a scale from 1 to 10, which is used in higher education in Slovenia. The products were also evaluated by two teachers (i.e. the teacher for the lectures and seminars and the teacher for the exercises). The evaluations of the students and the teachers of the pedagogical classes were compared. An example of an analysis rubric and the evaluation criteria are shown in Table 1.

Table 1: Analysis rubrics and evaluation criteria for 3D visualizations.

Analysis rubrics	Criteria for achieving grades from 6 - sufficient to 10 - excellent.
1. Študent/ka je cilje projektnega dela na temo Pokrajine / Landscape vizualiziral/-a: 4 Zelo kakovostno 3 Večinoma kakovostno 2 Delno kakovostno 1 Ni kakovostno 2. Študentka/študent je modele scene predstavil/-a glede na celoten koncep projekta: 4 Zelo natančno, z veliko detajli 3 Večinoma natančno, z nekaj detajli 2 Delno natančno, z malo detajlov 1 Ni natančno in brez detajlov 3. Študentka /študent je nivo materialov in tekstur uprizoril/-a v vizualizacijah: 4 Zelo Detajlno 3 Zmerno Detajlno 2 Minimalno Detajlno 1 Pomanjkljivo Detajlno 4. Ocenite kakovost in smiselnost tekstur in materialov, ki so uporabljeni v vizualizacijah: 4 Realistično 3 Sprejemljivo 2 Potrebuje izboljšave 1 Zelo nerealistično 5. Ocenite upodobitev osvetljevanja in luči na sceni: 4 Natančno, atmosfersko z veliko mero smiselnosti osvetljevanja 3 Rahlo ne v skladu s sceno in modeli ter teksturami in materiali na sceni 2 Precej ne s sceno in modeli ter teksturami in materiali na sceni 1 Neuporabno brez smisla za virtualno osvetljevanje	**Grade 10** - Geometry: with a lot of details, relief structures are solved with geometry, objects of more complex shapes (characters, demanding technical objects), significant use of digital sculpting; Textures and Materials: Advanced and physics-based materials and textures with details, UV mapping or digital painting; Lighting: advanced lighting techniques, global lighting, volumetric effects, caustics. **Grade 9** - Geometry: with many details, relief structures are solved in places with geometry, objects of more complex shapes (characters, demanding technical objects), use of digital sculpting; Textures and Materials: Advanced and physics-based materials and textures with details, UV mapping or digital painting; Lighting: advanced lighting techniques, global lighting. **Grade 8**- Geometry: with some details, objects of moderately complex shapes (middle LOD), digital sculpting in places; Textures and Materials: Advanced and physics-based materials and textures with details, UV mapping and folder usage; Lighting: advanced lighting techniques, global lighting. **Grade** 7- Geometry: simple geometry, objects without complex shapes (Low LOD), no digital sculpting, geometry errors in places, visible artifacts; Textures and materials: use of colors for textures, use of projection mapping, no use of maps or only in places, in places errors in textures and materials; Lighting: local lighting, without volumetric effects, harsh shadows, etc. **Grade** 6 - Geometry: very simple geometry, objects without complex shapes (Low LOD), no digital sculpting, geometry errors, visible artifacts; Textures and materials: use of colors for textures, use of projection mapping, no use of maps or only in places, errors in textures and materials; Lighting: local lighting, without volumetric effects, lighting irregularities, sharp shadows, etc.

When creating the questionnaire on students' opinions on the implementation of peer assessment, we started from the proposal given by Digitalna UL (digital support of the University of Ljubljana), which we adapted with the aim of focusing on peer assessment. The survey contained 17 questions, of which 4 questions were directly related to the implementation of peer assessment, while the other questions were more general in nature and related to the use of ICT in the course or the implementation of the course itself. Students rated on a scale of 1 to 5, with 1 meaning that they disagree with the statement and 5 meaning that they fully agree. The survey on opinions about the implementation of peer evaluation was sent to students in September 2024. Despite repeated requests, only 10 students completed the survey.

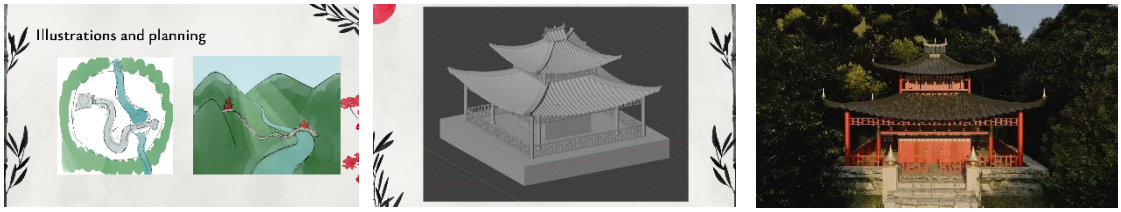
3. RESULTS

The results of the concepts and ideas during the semester and at the end of the semester in the form of renderings are shown in Figure 1, along with references, base models, and renderings that were evaluated by both students and teachers.

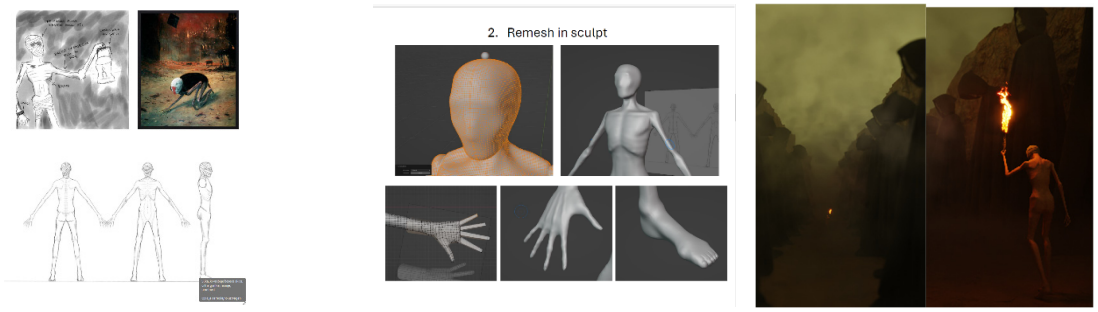
Show 1 – Initial ideas

Show 2 - Models

Show 3 - Final renderings



Author: Sara Klepac



Author: Max Pozderec

Figure 1: Initial ideas, models and final renderings using the example of two students' project work.

In answering the survey, we focused on questions directly related to the implementation of peer assessment and the use of ICT in the course. Students used a number from 1 to 5 to indicate how much they agreed with the following statements. Value 1 stands for the answer "I do not agree at all", value 2 for the answer "I do not agree", value 3 for the answer "I can not decide", value 4 for the answer "I agree" and value 5 for the answer "I completely agree".

Figure 2 shows the students' agreement with the following statements about the general use of ICT in study tasks:

I enjoy working with ICT - statement 1, I have no problems working with ICT - statement 2, I like to use ICT - statement 3, I think I know how to use ICT well - statement 4, When we use ICT in exercises/seminars/lectures, I prefer to leave the work to my colleagues - statement 5, Working with ICT is boring - statement 6, I prefer to avoid working with ICT rather than actively engage in work - statement 7, In order to feel more confident in using ICT, more time should be devoted to independent work with ICT in exercises/seminars/lectures - statement 8, It would be more useful if, instead of ICT, forms of work that do not involve the use of ICT were used in the pedagogical process - statement 9, More attention should be paid to training students to work with ICT in the study process - statement 10, The use of ICT in the course made it easier for me to communicate with the teacher (e.g. Moodle, MS Teams, Forms) - statement 11, Using ICT made it easier for me to follow course announcements (e.g. Moodle, MS Teams, Forms) - statement 12, By using the Internet, I can better follow the latest developments in my field of study - statement 13, Thanks to the use of ICT, I can start learning anywhere - statement 14, In general (we), the use of ICT in this course enabled the study material to be organized in a way that made sense to me - statement 15, Overall, the use of ICT in this course increased the frequency of my interaction with the course instructor and other students - statement 16, The use of ICT increases the possibilities of cross-curricular integration within the study program - statement 17, In this course, I used ICT (shows on MS Teams, MS Forms peer assessment, shows on Moodle and Moodle workshop) to continuously check my understanding of the study content, on the basis of which I planned the further learning process - statement 18, In this course, I evaluated my own work using ICT (submissions on MS Teams, MS Forms peer assessment, submissions on Moodle and Moodle workshop), based on which I upgraded my knowledge - statement 19, In this course, I evaluated the work of my peers using ICT (MS Forms peer assessment, Moodle workshop) - statement 20, In this course, using ICT (shows on MS Teams, shows on Moodle), I received feedback from the course provider about my work (assignments, products, etc.) - statement 21, I was able to monitor my learning progress in this course - statement 22.

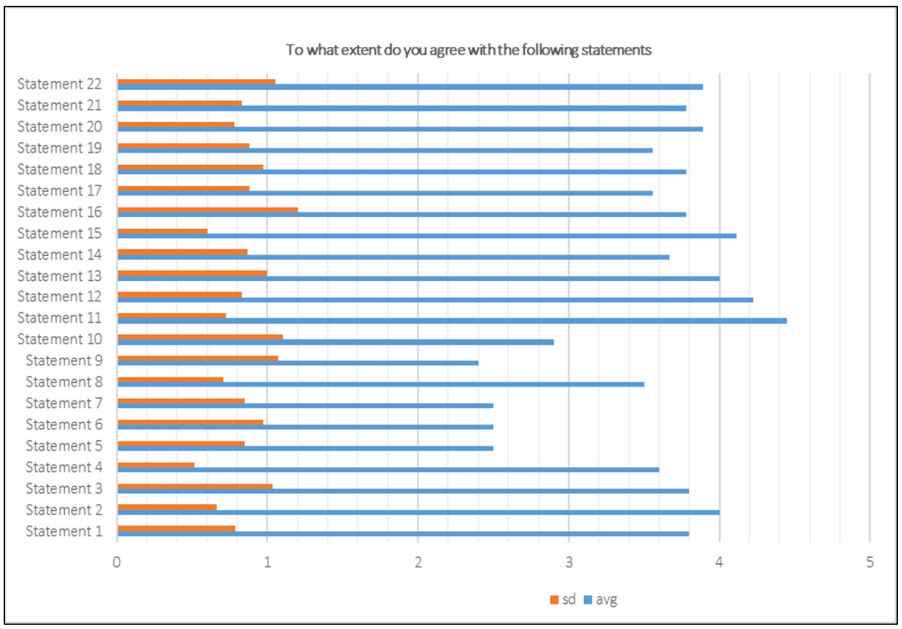


Figure 2: Use of ICT by students (sd-standard deviation, avg-average value, No. of respondees=10)

Figure 3 shows the extent to which students were involved in the use of ICT technologies during the course semester. Here in Figure 3, activities 1-4 represent the following statements:
Activity 1 – "Involved in a real-time (formative) test of knowledge with the help of ICT, which allowed you real-time feedback", Activity 2 – "Involved in the final (summative) assessment of knowledge with the help of ICT", Activity 3 – "Evaluating the work of peers using ICT", Activity 4 – "Evaluating your own work using ICT".

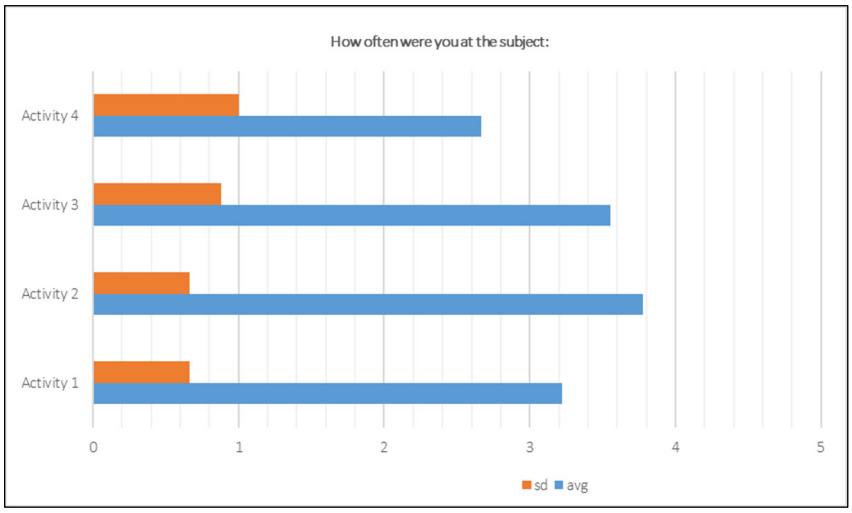


Figure 3: Students' evalutation of the invovlement of ICT methodologies (sd-standard deviation, avg-average value, No. of respondees=10)

Figure 4 presents methods for assessing student satisfaction with teaching:
Method approach 1 – The assessment method of this course (e.g. live, distance learning, combined study method, hybrid study method), Method approach 2 – Implemented activities with ICT- supported peer assessment in the course, Method approach 3 – The use of ICT- supported peer assessment to support the learning process, Method approach 4 – Communication with peers (classmates) during the assessment (interim and final results) of the course.

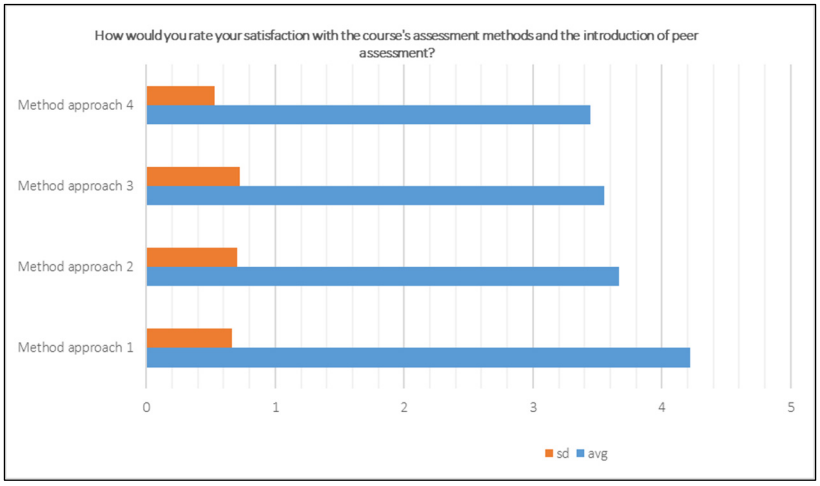


Figure 4: Course's assessment methods (sd-standard deviation, avg-average value, No. of respondees=10)

4. DISCUSSION

Both the midterm and final submissions of the students showed moderate student engagement in fulfilling course obligations. Figure 1 shows the midterm and final results of the two projects that received the highest grades. We found that most students prepared the material for both shows at the last minute, just before the show, which suddenly took place on the MS Teams (Assignments) platform. A comparison of student and teacher evaluations of the products showed that students rated each other's work slightly better. The average grade given by the students to their classmates' project work was 8.45 (sd 0.62), while the average grade given by the teachers was 8.30 (sd 0.90).

The results in Figure 2 show that students have no problems with the use of ICT and are happy to include it in their work process. They agreed that the use of ICT in the course made it easier for them to communicate with the teacher follow the messages in the course, and they were able to follow the innovations in their field of study better and organize their study materials more easily and meaningfully.

The survey results presented in Figure 3 show that students actively participated in the ongoing and final assessment of knowledge using ICT. They also actively participated in evaluating the work of their peers. Participation in ICT-based feedback on project work and summative assessment was rated by students as 3.21 and 3.68 respectively. Participation in peer assessment was rated 3.54 and the evaluation of their own work was rated 2.65.

Figure 4 shows that the students were very satisfied with the method of assessment in the subject Basics of 3D modeling by the teachers (grade 4.21). They were slightly less and therefore moderately satisfied with the activities carried out with ICT-based peer assessment in the subject (grade 3.65) and with the use of ICT-based peer assessment to support the learning process (grade 3.47). They were least satisfied with the communication between the peers during the assessment (grade 3.42).

We were supported by experts in educational science in the design, procurement of suitable procedures and implementation of the peer evaluation. Only in this way was it possible to successfully integrate the process. It was very important to clearly define the evaluation criteria. The results showed that targeting students and defining the introduction of peer evaluation is the key to successful implementation. It was also found that the introduction of peer evaluation alone is not enough to improve student interaction, but that it is necessary to motivate students to evaluate each individual project. In our experience, we had to encourage students to grade the project work for each participant individually so that they actually did so (even if they used their mobile phones to access the evaluation questionnaires). A comparison of the number of grades given by students for their classmates' project work fell by 50% at the end of the course compared to the beginning, despite the continued assessment of grading. The result opens up possibilities for further research on how higher assessment motivation could be maintained throughout the class despite the use of an ICT-based assessment method. However, the results showed that the grades given by the foreign teachers corresponded relatively well with the grades given by the students to their classmates' project work. In any case, it was noticeable that the students rated their classmates' products slightly higher and that the range of grades was narrower (most grades 8 and 9, i.e. very good) than the teachers' grades (greater proportion of grades 7, i.e. good).

5. CONCLUSIONS

The purpose of the research was to examine the impact of introducing ICT-assisted peer evaluation in regular semester and reviews of interim and final results of project concepts and visualisations in the subject with the topics about 3D computer graphic and visualisation. With this aim, we have created peer assessment rubrics that provide a structured assessment tool. The assessment rubrics and clearly defined assessment categories helped us to assess student products (by teachers and students) in a consistent way. We propose that in the definition of the assessment approaches, categories, criteria and rubrics, the basics of educational sciences should be involved as the didactics is crucial beside technical part for the quality of the assessment. Based on our results, the students of the course of 3D modelling are highly confident with the use of ICT technologies. As expected, the students are significantly including ICT in studying occupations of 3D computer graphic. Our results showed that there was a tendency of higher grades that students use to evaluate their peers' project work compared to the grades given by the course teachers. The range of student marks was smaller than the range of teachers' marks, what might show also the lower objectivity of the students' marks.

Students were positive about using ICT-oriented methods to evaluate their classmates' work but were less confident in evaluating their own work (lower scores).

Based on the results of the introduction of the rubrics and evaluation criteria for peer assessment, we believe that the method is important for the development of the course and especially for the more active participation of students in self- and peer- evaluation, which also increases their motivation to deepen their work in the course. We see possibilities for improvement in the redefinition of analytical rubrics, a clearer presentation of the goals of peer evaluation, a reorganization of the submission and evaluation method in MS Teams, and motivational strategies that would engage students more seriously in the evaluation process for the duration of the entire class period devoted to evaluation.

6. ACKNOWLEDGMENTS

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