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The use of generated 3D models in teaching the development of AR/VR applications

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ABSTRACT: This study was focused on the use of generated 3D models in teaching to develop AR/VR applications, and the impact of these models on learning. In this article are considered the issues of choosing the most suitable artificial intelligence tools and the text-to-3D generation groups to generate 3D models, and the integration of these models into a virtual environment with an emphasis to investigate their functional, interactive and physical features. The article presents the results of a pedagogical experiment to determine the influence of these tools on the learning process when developing AR/VR applications. The experiment involved 72 university students, who had taken such subjects as Computer Graphics and 3D Modelling, and Augmented and Virtual Reality. A comparative analysis of 11 neural networks for 3D modelling helped to identify common requirements for them to improve the learning process and make recommendations that were later reflected in students' project work. The assessment results are positive - the teaching quality was over 80% for all set criteria, and 83% of the students agreed that AI tools for generating 3D models are helpful in creating AR/VR applications.

INTRODUCTION

Due to the rapid development of digital technologies, contemporary education is expected to foresee the necessary skills of future specialists and foster potential emerging technologies. At this time, generative systems based on artificial intelligence can be applied in new ways by integrating with advanced technologies and facilitating human activity. One of these approaches is teaching 3D modelling which is widely used in various industries. Undoubtedly, studying 3D modelling serves as the basis for mastering virtual and augmented reality technologies, various simulators and three-dimensional spaces. In this case, generative solutions can also help students to accelerate their learning of 3D modelling by making it easier to complete basic modelling tasks, while allowing them to focus their efforts on more complex operations.

LITERATURE REVIEW

In his research, Tang et al describe a number of difficulties in learning the concept of 3D modelling and note that creating even simple 3D models requires mastering professional software, such as 3D Max or Maya, and is unreasonably labour-intensive [1]. Stigeborn in his degree project points out that this labour-intensive work slows down the progress of developing game engines, hindering developers and requiring them to study 3D modelling. It also supports automatic generation of 3D models [2].

Artificial intelligence tools can improve developers' productivity by meeting three basic requirements, which are satisfactory quality, fast generation time and ease of use [3]. Generative artificial intelligence tools are capable of autonomously creating new content, texts, images, audio and video by filling gaps in the development of the metaverse [4].

This need has led to the rapid development of research on generative 3D modelling. Therefore, contingently, 3D modelling instruments can be divided into three main groups:

- Text-to-image generation. Such transformations are possible through diffusion models and complex semantic concepts to create high-quality images and scenes.
- 3D generative models. This can be achieved through 3D voxel grid, point clouds or octree representations approaches based on teaching data in the form of 3D resources, which are subsequently generated in a 3D model. The main disadvantage of such approaches is the large amount of rendering that slows down query processing.
- Text-to-3D generation. The synthesis of 3D models occurs by learning parameters and shapes from text input. Lin et al were able to improve the synthesis of text in 3D through DreamFusion using the Magic3D method, which allows one to create high-quality 3D models much faster by achieving higher resolutions [5].

In their study, the authors of this article used the latter type of 3D model generation since entering the required parameters is more common and applicable in training.

Long et al proposed a system that integrates an artificial intelligence module and augmented reality visualisation for robotic surgery training [6]. Such significant contribution to the field of medicine is worth noting since it highlight the importance of navigating the trajectory and determining the coordinates of 3D objects during its development [7].

In their work, the authors pay particular attention to teaching students 3D modelling with the implementation effect as close as possible to reality, and the physical features of models, such as gravity in various environments, collision, inertia of objects, etc, by using primitive generative models. After all, the lack of stereoscopic or spatial representation of simulated 3D objects often complicates their perception in a virtual environment [8], moving it away from the originality of interaction with the user [9]. Moreover, according to the results of using the root-mean-square error (RMSE) method for assessing accuracy, there are difficulties in placing 3D models in an augmented environment due to the spatial mismatch between the virtual and real environments [10]. Research conducted at the University of Colorado Boulder revealed that it is extremely important to develop spatial thinking skills in students studying 3D modelling [11]. For example, in the field of building design and architecture, a preliminary visual representation is significant and has been successfully implemented with building information modelling (BIM) [12].

All this indicates the need to place emphasis in the learning process on the properties of 3D models in a virtual environment, rather than exerting great effort and spending unnecessary time on creating the 3D models by students themselves, especially when there are generative systems that facilitate and speed up the work of their creation.

The purpose of this study was to examine the use of generative 3D models in teaching the development of AR/VR applications. The research problems/questions were:

RQ1: Selection of optimal tools for generating 3D models;
RQ2: Development of AR/VR application using generated 3D models;
RQ3: Influence of the use of generative 3D models on the learning process in developing an AR/VR application.

METHODOLOGY

To examine the use of generative 3D models comprehensively and answer the research questions, the study consisted of the following stages:

Stage 1. Technological aspects: Analysis of artificial intelligence tools for generating 3D models. Selection of suitable tools to use in the learning process and for further use in the development of AR/VR applications.

Stage 2. Methodological aspects: Determining courses/subjects where the above-mentioned AI tools will be used, selecting academic groups and determining the teaching methods.

Stage 3. Content aspects: Determining the proposed tasks for students that improve their skills in developing AR/VR applications through the use of generated 3D models.

Stage 4. Learning outcomes: Determining students' achievements according to the developed assessment scale.

Stage 5. Feedback. Surveying students' perceptions.

The first stage of the study was aimed at conducting an analysis of generative tools for 3D modelling. A collection of various recommendations, a review of popular technological Web sites and user requests prompted the authors to pay special attention to the following main criteria: the type of conversion to a 3D file, the 3D file extension available for subsequent editing and the speed of formation of the 3D object. In addition, 11 neural networks were analysed (Table 1) which are designed to generate 3D models.

Table 1: Comparative analysis of generative tools for 3D modelling.

<table>
<tr><th>No.</th><th>Name</th><th>Conversion type</th><th>3D export format</th><th>Generating speed</th></tr>
<tr><td>1.</td><td>3DFY.ai</td><td>Text to 3D</td><td>.glb, .fbx, .blend</td><td>10 sec</td></tr>
<tr><td rowspan="2">2.</td><td rowspan="2">Meshy</td><td>Text to 3D</td><td rowspan="2">.glb, .fbx, usdz</td><td>180 sec</td></tr>
<tr><td>Image to 3D</td><td>191 sec</td></tr>
<tr><td rowspan="3">3.</td><td rowspan="3">Luma AI</td><td>Text to 3D</td><td rowspan="3">fbx, blend, stl, obj, gltf, usdz</td><td>9.02 sec</td></tr>
<tr><td>Image to 3D</td><td>9.37 sec</td></tr>
<tr><td>Video to 3D</td><td>8.67 sec</td></tr>
<tr><td>4.</td><td>Alpha3D</td><td>Text to 3D</td><td>.glb</td><td>60 sec</td></tr>
<tr><td rowspan="2">5.</td><td rowspan="2">Meshcapade</td><td>Text to 3D</td><td rowspan="2">obj, fbx</td><td>36 sec</td></tr>
<tr><td>Image to 3D</td><td></td></tr>
</table>

6.	Masterpiece X	Text to 3D	.glb, .fbx, usdz	120 sec
7.	Spline	Text to 3D	jpg/png, mp4/gif ltd/usdx	120 sec
8.	Sloyd	Text to 3D	obj, glb	30 sec
9.	Brand XR	Image to 3D	gltf, obj	10 sec
		Video to 3D		
10.	CSM 3D	Text to 3D	obj, glb, usdz	35 sec
		Image to 3D		
11.	DPT Depth	Image to 3D	obj,blend	36 sec

Particular attention was paid to the adaptability of the generated 3D model for importing into the development environment Unity and Unreal Engine within AR/VR applications. The export formatting is provided in Table 1. Moreover, the speed of generating a 3D model was measured using the same request for all presented platforms. Based on the results of comparing all 3D model generators, the Luma AI neural network (Figure 1) was outstanding since it generates everything in the required formats and at average speed.

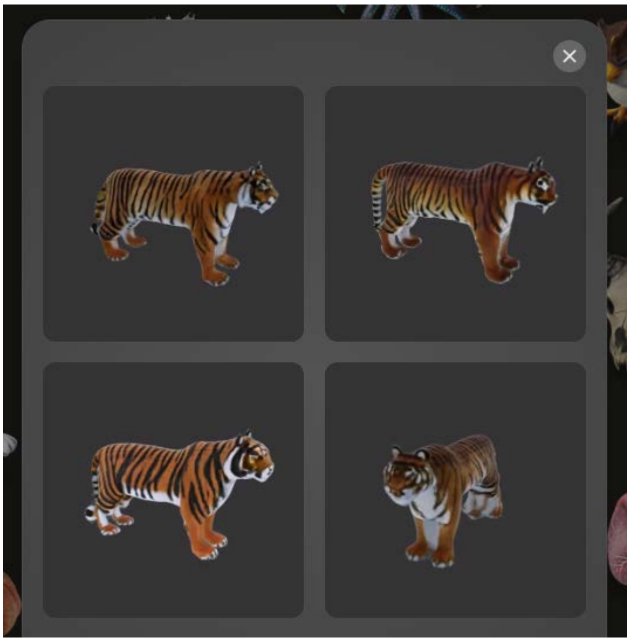

Figure 1: Luma AI 3D model generator.

In the second stage, a targeted group of undergraduate students were identified. Particularly important was that they were studying similar subjects, which were 6B01506-Informatics, 6B01514-Informatics-Robotics and 6B01505-Physics-Informatics, and they also studied the development of AR/VR applications during the Augmented and Virtual Reality subject in their fourth academic year. There were 72 participants in the study, all of them were students who developed AR/VR applications in project-based learning. A subject with five European Credit Transfer and Accumulation System (ECTS) points made it possible to conduct a pedagogical experiment in consensus with the curriculum. It is important to note that the main prerequisite to for this subject is a preliminary subject Computer Graphics and 3D Modelling, which was undertaken in the third academic year. This implies that students have already developed 3D modelling skills that require further development and application.

The content of students' project work was determined at the third stage of the study. Students developed various AR/VR applications using Unity or Unreal Engine with integration of Vuforia SDK, Easy AR. The topics of the projects were as follows: AR game development, 3D character animation in AR/VR, Virtual teleportation, Structure of chemical elements in an AR environment, and others.

As the development of an AR/VR application is particularly focused on its functionality and expanding the student's spatial vision, students also had to meet the following seven requirements while developing their projects:

1. Using generative AI tools for 3D modelling.
2. Fully functioning AR/VR application.
3. Stability of connection between integrating services and an AR/VR application.
4. Intuitive and attractive AR/VR application interface.
5. Clear and adapted AR/VR application code.
6. Implementation of a type of interactivity with virtual objects of an AR/VR application.
7. Adding physical properties to 3D models of an AR/VR application.

For example, the implementation of a project visualising the chemical compound of water molecules, which consists of two hydrogen atoms and one oxygen atom can teach students to use primitive models that are generated using the Luma AI or 3DFY.ai neural network, with more advanced functionality achieved by adding physical properties and programming for MultiTarget (Figure 2).

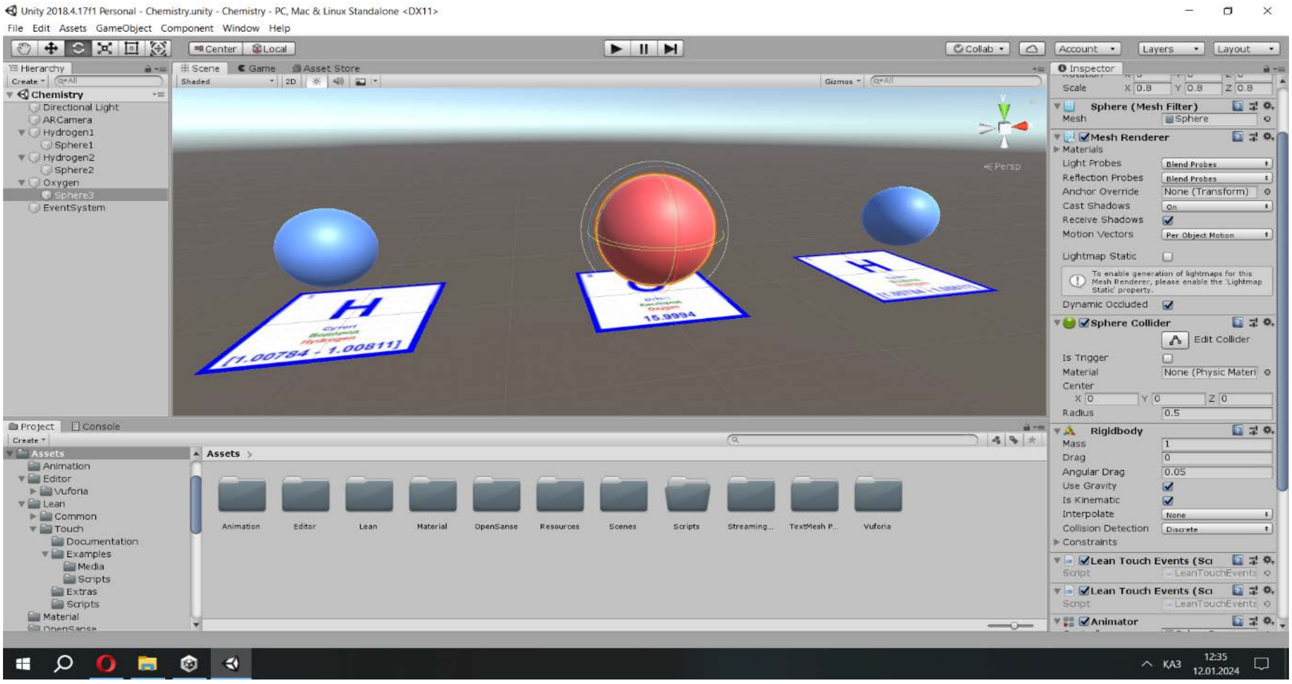

Figure 2: MultiTarget.

MultiTarget - simultaneous recognition of several targets, followed by adding and building interactions between individual AR/VR objects. Changing the parameters of the Max Simultaneous Tracked Image and Max Simultaneous Tracked Objects allows one to expand their number.

While running this AR application, one can observe that if the distance between the ImageTarget is more than 1 cm, then the virtual objects remain in the form of atoms (Figure 3). However, if the distance is less than 1 cm, then the atoms combine into a water molecule (Figure 4).

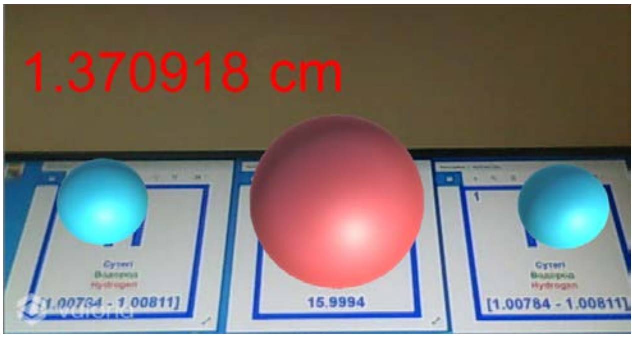

Figure 3: ImageTarget distance greater than 1 cm.

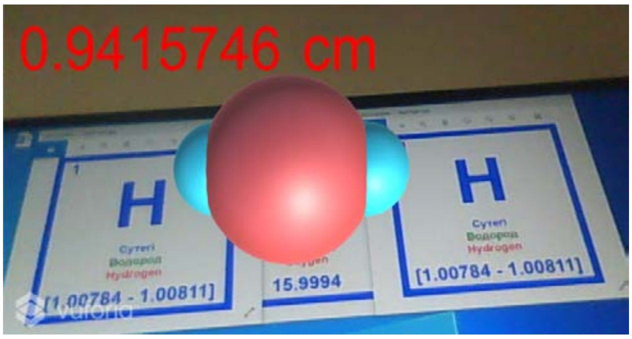

Figure 4: ImageTarget distance less than 1 cm.

It is important to note that in all projects, students used generated 3D models to varying degrees which allowed them to optimise their projects and focus more on implementing an AR/VR application.

At the fourth stage of the study, students' work was assessed according to the developed project evaluation scale. The rating scale included six main criteria with detailed explanations for the following types of ratings: excellent (90-100%), good (70-89%), satisfactory (50-69%) and unsatisfactory (0-49%). The criteria include project purpose, analysis of existing solutions and methods, methods, quality of the result, individual contribution to the project, and special criteria that demonstrate the fulfilment of the requirements for the project before the start of its implementation. Students' works were assessed using the presented scale and continuous feedback was provided during the implementation of project work.

At the last, fifth stage of the study, a survey was conducted to find out students' opinions about the impact of the AI tools used to generate 3D models on the learning process of developing an AR/VR application. The questionnaire contained 11 questions for self-reflection in various formats, such as multiple choice, multiple response, fill in the blank and a Likert scale.

Summarising all stages of the research, the authors can conclude that the use of AI-generated 3D models for the development of AR/VR applications was examined from various aspects, especially highlighting its impact on the learning process.

RESULTS AND DISCUSSIONS

A study of the impact of using 3D models generated for the development of AR/VR applications on the learning process showed a positive trend.

As a result of the analysis of neural networks that are designed to generate 3D models, three main characteristics were identified, such as 1) the type of transformation; 2) available extensions for 3D export; and 3) the speed of generating 3D models. These characteristics help to identify the required AI tool to enhance the learning process. A comparison of 11 neural networks revealed that now in the development of AI, Luma AI is a more suitable solution for using in the development of AR/VR applications. This is because it exports 3D models in fbx, blend, stl, obj, gltf, usdz formats and supports convenient conversion types, such as text to 3D, image to 3D, video to 3D.

Also, similar content in the subjects Computer Graphics and 3D Modelling, and Augmented and Virtual Reality helped students to improve the necessary skills for creating AR/VR applications. This is evidenced by the completed project works of students which were assessed according to the developed scale including six criteria. Each criterion has four assessment ranges.

According to the results of evaluating students' project work, 18 students received a grade of excellent (90-100%), 43 students received a grade of good (70-89%), 11 students received a grade of satisfactory (50-69%) and no student work was marked as unsatisfactory (0-49%) (Figure 5).

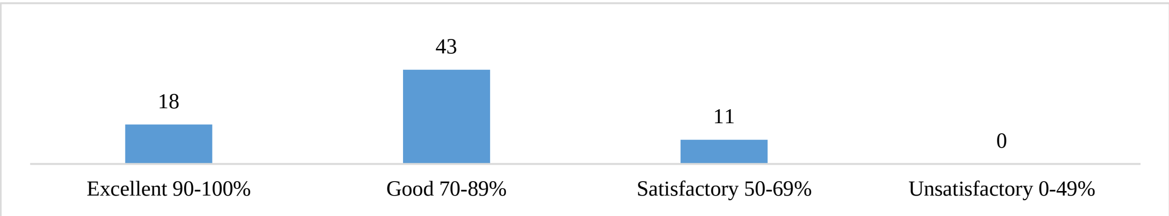

Figure 5: Assessments results of students' project work.

If one presents the achievements of 72 students in the context of the above presented criteria, one can see that the quality of education according to the criterion *Purpose* is 83.65%, *Analysis of existing solutions and methods* - 83.25%, *Methods* - 84.54%, *Quality result* - 84.98%, *Independence, individual contribution to the project* - 83.83%, and *Special criteria* - 82.33% (Figure 6).

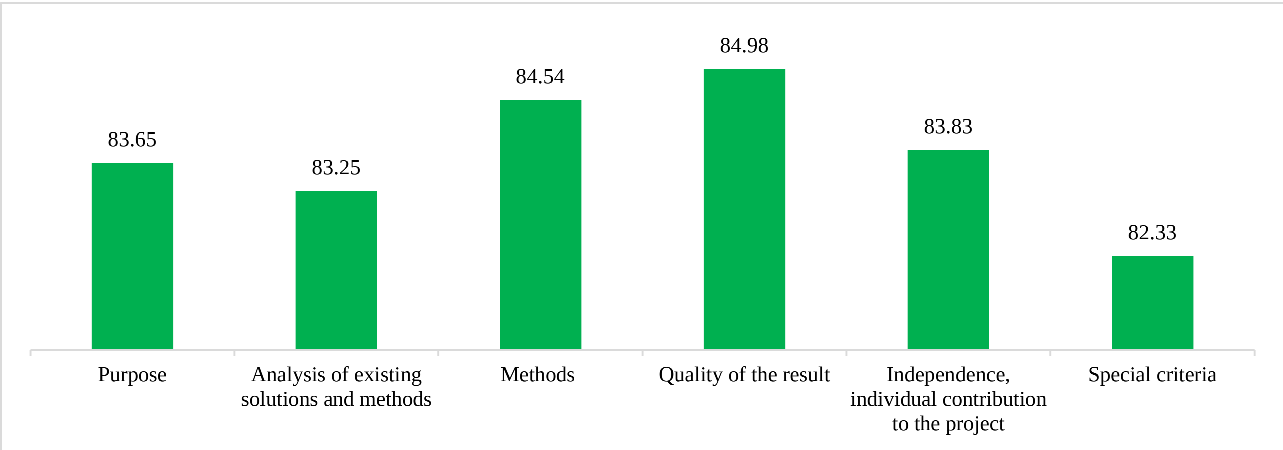

Figure 6: The quality of teaching in regard to the presented criteria.

Overall, 84.7% of the 72 students showed *excellent* or *good* results when completing a project to develop AR/VR applications using generated 3D models. This is one of the indicators of a correctly chosen strategy for using the design method in conjunction with artificial intelligence tools.

To the question: *In your opinion, how necessary is a high level of knowledge and skills in 3D modelling to create AR/VR applications?*, the majority of the students (61%) responded that *It is extremely necessary, because without it,* *it is impossible to create a high-quality AR/VR application*, while over one third (38%) responded that *The need is moderate, since it is enough to be able to edit basic models in AR/VR*, and only 1% of the respondents supported *Low need since there are already ready-made 3D models that are more often used* (Figure 7).

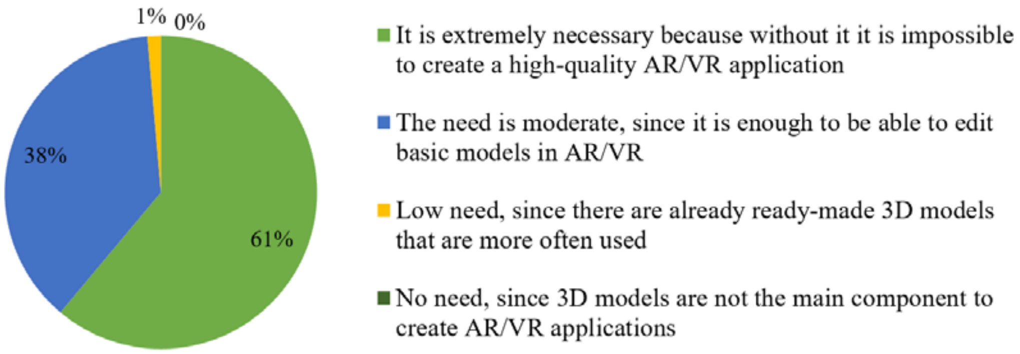

Figure 7: In your opinion, how necessary is a high level of knowledge and skills in 3D modelling to create AR/VR applications?

Moreover, 83% of the respondents agreed that AI tools for generating 3D models help in creating AR/VR applications (Figure 8).

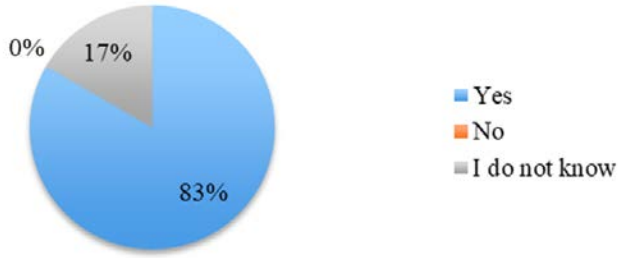

Figure 8: Do you agree that AI tools for generating 3D models help in creating AR/VR applications?

Based on the results of the survey, it was found that the most used AI tool for generating 3D models when implementing design work was Alpha3D. It was selected 23 times (Figure 9).

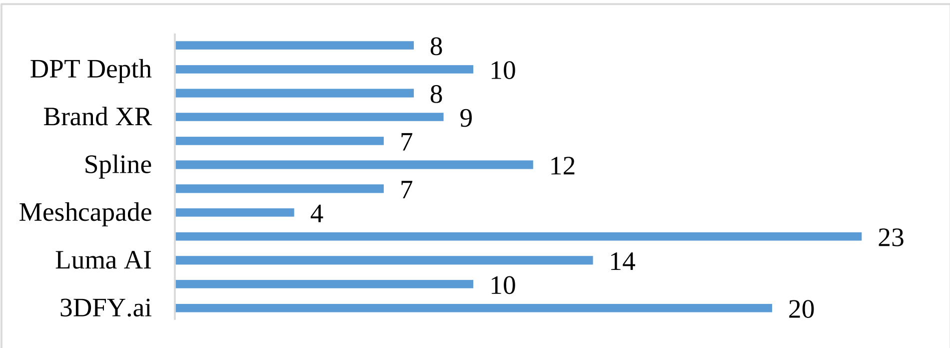

Figure 9: Which of the proposed AI tools for generating 3D models did you use in your project?

The respondents were also asked to assess the usefulness of neural networks for generating 3D models in the process of learning to develop AR/VR applications on a Likert scale from 0 (completely useless) to 10 (extremely useful). The results show that 34 respondents rated it 10, 13 rated it 9, 12 respondents rated it 8 points (Figure 10).

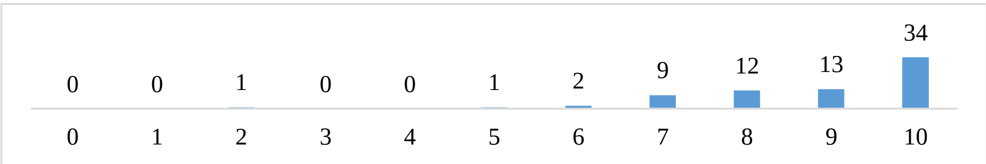

Figure 10: How useful do you think neural networks can be for generating 3D models in the process of learning to create AR/VR applications?

Interpreting the above results, the authors can state that the sequence of stages of the study helped to fully consider all its aspects. The use of generative 3D models in teaching the development of AR/VR applications helped to improve the learning process by optimising the creation of 3D models and improving their physical features in a virtual environment, thereby achieving the goal of the study.

CONCLUSIONS

Improving the learning process for AR/VR application development required the use of the best and most suitable tools to speed up the labour-intensive process of creating 3D models, thus releasing time for learning more complex processes. The use of neural networks that generate 3D models in different formats for export with convenient conversion and at an acceptable speed has been an applicable solution for this.

A comparative analysis of 11 neural networks for 3D modelling helped to identify common requirements for them to improve the learning process, and make recommendations which were later reflected in students' project work. According to the assessment results, the teaching quality was over 80% for all six criteria which is a positive result in achieving the goal of the study. Moreover, 83% of the students agreed that AI tools for generating 3D models help them in creating AR/VR applications.

It is suggested that future research may consider the ways to improve the quality of the generated 3D models for further use in teaching the development of AR\VR applications.

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