Augmenting Student Education Using the RealityScan Application for Generating 3D Content

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Abstract **- Augmented reality in education is surging in popularity in schools worldwide. Through augmented reality (AR), educators are able to improve learning outcomes through increased engagement and interactivity. Augmented Reality (AR) in education features aspects that enhance learning abilities like problem-solving, collaboration, and creation to better prepare students for the future. It is also good for traditional pedagogy focused on technical knowledge and proficiencies.**

An analysis is made on the innovative technology for generating 3D models - the RealityScan application by Epic Games for iOS. Several characteristics and functionalities of the application are described and tested. Methodologies and workshops based on them are created and presented.

A process of including the aforementioned technologies in the curriculum and easing the students into using such tools in their future professional career is created and partially implemented. Several benefits of becoming familiar with such technologies are analyzed. A conclusion is made on several critical points that have to be addressed when implementing the necessary steps for improving the education system using AR.

Keywords - augmented reality; education methodology; 3D models

I. INTRODUCTION

Institutions are currently facing the challenge of motivating and encouraging students to engage in professional careers in AECO-Architecture, Engineering, Construction, and Operations sectors as they do not find jobs appropriate to their degree. One of the reasons is the students' lack of proper intuition and insights as a skilled professional. A solid choice for improving the student's level of engagement in the classroom and simultaneously providing them with the basic necessary experience needed to make them a valuable future cadre is making use of Augmented Reality (AR) applications. One of the available technologies that are proven to fulfill our criteria are Virtual Reality (VR), Augmented reality (AR) and Mixed Reality (MR). Studies on the topic have been analyzed and it has been concluded that our students will benefit greatly if they are able to engage in AR learning.

AR makes learning itself more engaging and fun. It inspires and engages students, thus making the learning process of STEM and coding easier, more enjoyable and better than it has ever been [1].

The next logical step in AR-based learning discovered from reviewing current literature is the development of applications that can enable personalized learning materials for both students and teachers. Several of the future technology challenges are user acceptance, proving the educational effect it has on learners, and further development of the frameworks used to develop these innovative applications. As the cost of hardware and software decreases, AR technology will become more affordable, thus allowing it to be widespread at all educational levels, especially in higher education. [2].

A bibliometric analysis of 1977 articles was performed, obtaining results of scientific productivity. The evidence showed a growing interest in studying the sustainability of AR in higher education. AR has been applied mainly in HE settings and compulsory levels of computer science education, as a resource to motivate students and to promote student learning.[3].

The usage of AR in training and teaching has allowed the development of different possibilities: 1. erasure of content which could make it difficult to obtain relevant information for the student to use; 2. generation of content that makes the information more understandable to the student; 3. giving the student the possibility to observe the object from different points of view and different angles; 4. facilitation of the generation of ubiquitous learning for the student; 5. the students' immersion in an "artificial" environment, such as simulators or laboratories; 6. an enriched printed material through different resources; 7. improvement of the way in which students learn through motivation; 8. learning objects that generate "prosumers" students instead of "consumers" of information. The potential offered by this technology is increased with its incorporation through different disciplines as well as the different educational levels in which they can be used. It should be noted that experiences and studies are most often conducted at the higher education level – in the universities [4].

Studies have shown that AR can have a consistently positive impact on student motivation. There are studies which prove that AR can specifically increase student engagement in science learning. The increase may be largely attributed to the elements of curiosity, fantasy, and control presented using AR technology, as student motivation may be directly influenced by using an attractive or stimulating medium or learning material [5].

A custom solution is considered for a later period in time, as the resources necessary to create one exceed the timeframe of this study. Furthermore, the data gathered using a ready-made solution would become a stepping-stone in furthering our investment in this type of technology as well as obtaining experience and constructing opinions on how to improve the process.

Our goal is to help students get familiar with 3D object generation and take into account the newest available solutions and software which help with reducing manual work. RealityScan is a perfect example of cutting-edge tool that is still being tested on production. Using it should help students recognize the flow of software development during its final testing phases and innovation. Higher education is the place to indulge in learning sufficiently complicated software for such purposes. Work on similar topics has been progressing at our university for a long time [6], and this research is a part of the next logical steps.

II. LAYOUT

A. Analysing available technologies

Our criteria for comparing different tools are several – 1) the cost of the application, 2) the availability of hardware to run the application on, 3) the viability of the application to be used as a learning tool in the curriculum and last, but not least, 4) the learning curve that will be necessary for both teachers and students to pass in order to understand and use the application Table 1. In order to evaluate the learning curve, we have consulted with other professors at our university and based on their extensive experience with working with students, the difficulties of learning the tools have been taken into account.

Application	Cost	Hardware requirements	Learning materials	Learning curve
RealityScan	Free	iOS compatible device (iPhone / iPad)	online video tutorials, no official documentation	Moderate, assuming the students previous experience
Nvidia NeRF	Free	Windows/Linux	A large number of available resources	High
Reality Capture	Paid	Windows	A large number of available resources and official documentation	Moderate-to-easy

Table1. Comparison between different software applications used for generating 3D models

An analysis of some of the available technologies is made and several of their peculiarities are described.

The company creating RealityScan advertises it as a transformative tool, which captures real-world assets for digital experiences. It is put into comparison to the traditionally complicated, technical, and labor-intensive process of doing so. As it released in its' beta version, RealityScan took users preferences about RealityCapture - fast and easy 3D SCANNING – and allowed it to be used by anyone with a smartphone, turning the cameras into an endless source of creativity. Some of the greatest features of this app are: free tool, no equipment needed, ease of use [7].

Neural Radiance Fields (NeRF [8]) are neural networks capable of generating three dimensional images or scenes from a set of two-dimensional images developed by NVIDIA. Using spatial location and volumetric rendering, the model uses the camera angle from the images to render the three-dimensional space of the scene.

All the described applications can export models to SketchFab – modeling platform for publishing, sharing, buying and selling 3D and AR content.

Reality Capture is a photogrammetry software application for Windows, developed by Epic Games. It enables the user to create ultra-realistic 3D models from a set of images and/or laser scans. It is possible to create virtual reality scenes, textured 3D meshes, orthographic projections, geo-referenced maps and much more from images and/or laser scans automatically. One of the limitations of the product is its' high price and the strict requirements to the level of equipment. As the software is heavy on consuming resources, a powerful video card is a must-have [9].

Several limitations of RealityScan are present in the current version. There is a limit to how many models can be exported to SketchFab - the intertwined 3D manipulation tool. Users are limited to 50 models a month per account. For educational purposes, this is not a severe drawback, and a form of licensing can be purchased if there is a need to expand. The application itself has a maximum of 200 photos per object, but our experience indicates that 100 photos are usually sufficient to generate an adequate scene containing it.

The quality is improved gradually the more photos are taken from different angles - the change is visible in the level of detail that is present in the finished model Figure 1.

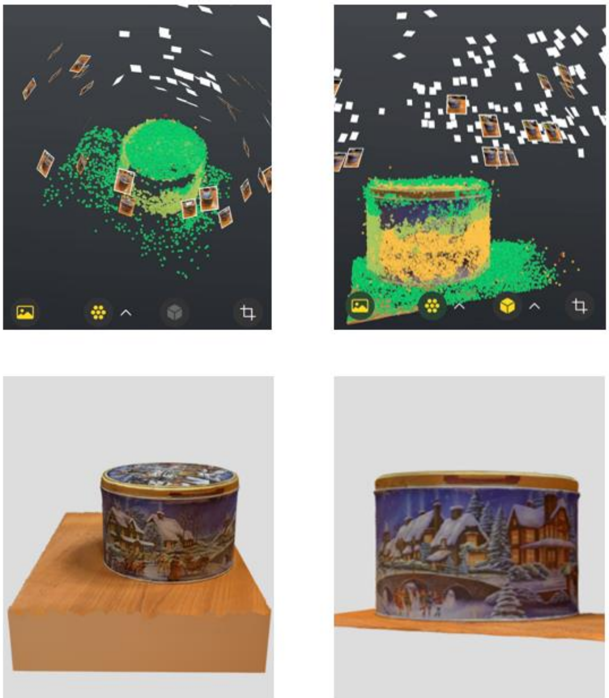

Figure 1. Comparison of three dimensional models generated using 100 photos (left) and 200 photos (right)

The SketchFab application supports a variety of exportable file formats. The default format is .fbx – FBX files typically contain mesh, material, texture and skeletal animation data, all of which are sufficient for fully creating, manipulating and modifying a 3D image. Another supported format is .glTF / .glb – the GL Transmission Format is designed for compact file size, fast loading, run-time independence and complete 3D scene representation. It is hailed by users as "the JPEG of

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3D," and can use both JSON / ASCII (.gltf) and binary file format (.glb) file extensions. SketchFab also allows exporting in .usdz – a 3D file format standard created by Pixar. It has been adopted by Apple as the main format for AR applications on iOS AR Quick Look. All of the formats described above are providing a good variety of choice in applications where the work with the models can advance. The SketchFab application is used as a "container" for the generated 3D models, it is recommended to be used in conjunction with RealityScan by its publishers.

B. Methodology

A methodology has been adapted to suit the needs of improving the students' abilities to work with advanced 3D graphic creation and manipulation software. It can be seen on Figure 2.

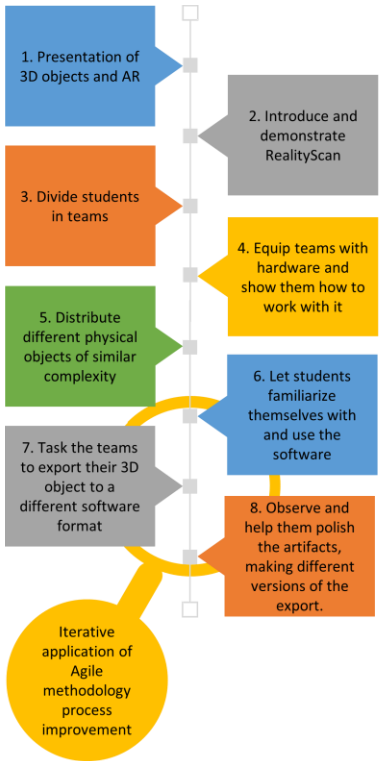

Figure 2. Adapted methodology for teaching and aiding students in their work with 3D creation and manipulation software

The first step of the methodology introduces students to the basic qualities and properties of three-dimensional objects represented in computers. Simple descriptions and types of technologies that make use of these models such as AR, VR, mixed reality, as well as some examples of them are shown. The second part of the theoretical preparation for the workshop introduces them to the software tool they would be using – RealityScan. Several examples on successful use of the software are described. A short tutorial is shown in order to let them gain initial insight into working with the tool.

The students are then divided in groups, distributed evenly among the available hardware. Our experience in separating students in teams for various projects, workshops and tasks has taught us that the best result can be achieved using groups of minimum two or maximum three students. The different teams are provided with a tool, capable of using the application and are educated in practice how to use it and gain advantage of its features. Each group is given a physical object of similar complexity to scan and are left for an appropriate time to experiment, use the tool and complete the task of scanning their assigned object, thus generating a 3D model successfully.

An iterative approach is used for the next part of the workshop – scanning the object and generating a model is the first step among several forming a feedback loop, giving the students the opportunity to practice their knowledge on agile methodology in practice (agile methodologies are processes that favor the iterative approach to finding and optimizing a solution to a problem). The next step requires the teams to export the object in format workable with Blender - a free 3D modeling software. This necessitates the use of their knowledge of different graphical formats and compatibility issues between the different software systems. The process itself is manual work intensive, but it improves their general expertise for working with 3D objects and manipulation tools, as well as stimulating their brain hand-coordination skills.

C. Further steps and expansion in other workshops

Witnessing the entire process of creating images from data is a prerequisite to visualizing the objects using AR. After the teams have completed their assigned tasks, they are required to export the objects to a software that generates QR codes to be used for visualizing the results through their phones. An app is used to show their creations as a part of AR, so that they can see the entirety of the implementation process. Several AR libraries are currently being analyzed for further research. A temporary testing is done using the AR JavaScript library organization in GitHub [10], as well as the "Mind AR JS" subsidiary, forked by HiuKim Yuen [11].

A preliminary version of a methodology has been created to aid the process of including the scanned object to another workshop project. It can be seen on Figure 3.

The process mainly relies on students having studied web development and application deployment in their previous classes, but detailed instructions are being prepared for their benefit. The teams of students have to take their exported object and include it in a scene using the provided open source library. After they finish the task of successfully simulating a scene on their local computer, they are encouraged to publish the application on the web for testing purposes. As Software Engineering students at the University of Ruse, they are already registered in Azure, the Microsoft cloud platform, as their accounts are set up in previous subjects, required in their curriculum. The use of other hosting platforms is also accepted, as many prefer Amazon Web Services or personal hosting environments. After they have succeeded with exposing their web project to the world wide web, the learners have to generate QR codes that will make use of the software library functionality for visualizing the models in AR. The next step is testing whether everything works in the expected manner, and the last step is the live testing using their own mobile device. The students have already been instructed on the use of Agile methodologies in other subjects, so they should be using a task management system to split their obligations in the team, monitor their work and progress and report on any problems that have arisen during testing or deployment.

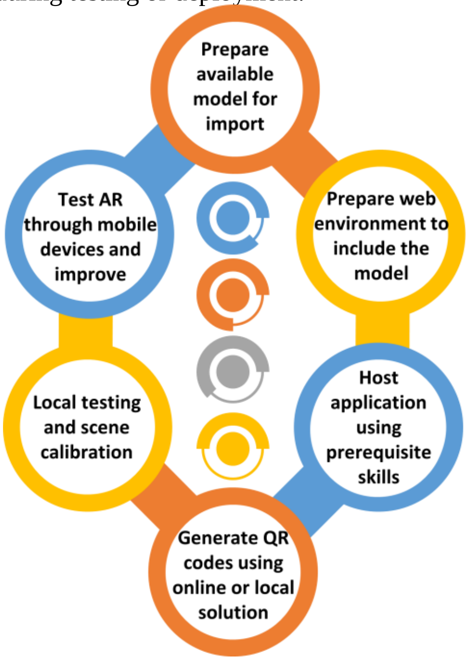

Figure 3. Methodology for training students to apply software engineering skills to the use and deployment of open source libraries aiding the visualization of 3D models in AR

D. *Work and study environment preparation*

A great implementation of the AR technology within RealityScan is the shown positions of photos that are already taken. This helps the users identify neglected angles that need to be addressed, as well as complements the application with the possibility to split the photogrammetry process in sessions, allowing pause and later continuation of the scanning.

Figure 4. , the entire process of capturing an object using RealityScan can be observed. After a proper object has been selected, it is put in a well-lit area, preferably on surface with color, which does not consume much light. It is also recommended that the object is of different color, compared to its environment in order to achieve the best results. The second part of the process on the figure shows a screenshot of the RealityScan capturing mode. Every photo already taken by the camera is displayed using AR, so that the operator can align the camera with less covered angles. This functionality has immense impact in improving the coverage of the object, especially when the operators are not qualified photographers. This further elevates the applications' qualifications to be used in education, where the students are not professionals and they need to start gaining valuable experience. The supportive use of AR in this case is possibly the most important factor that influenced the decision to include AR in the students' curriculum – seeing its' assistive qualities when doing practical work related to computer graphics and 3D model generation.

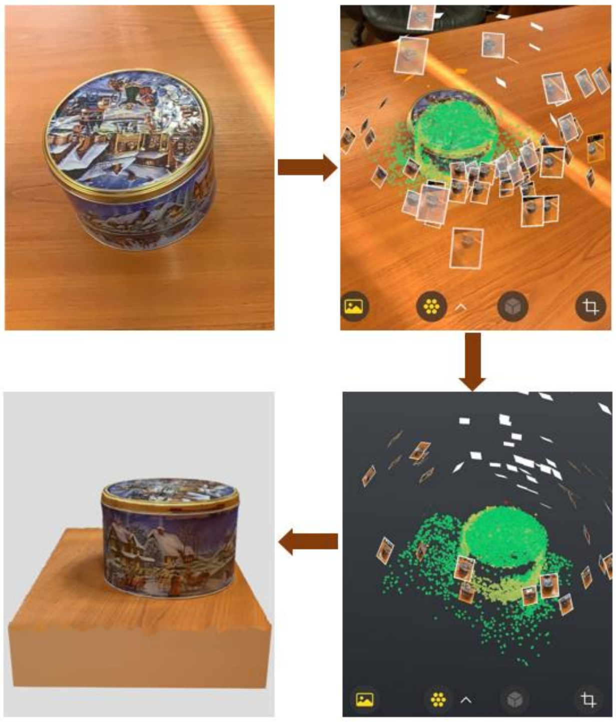

Figure 4. The different stages of converting a real life object to a 3D model in SketchFab using RealityScan

After photos of the object from different angles have been made, the next step is improving the quality of the coverage in the zones with red or yellow indicators. As shown in the third step of the process in Figure 4. , the environment can be turned off, and we can focus on which area of the model has to be worked on. A temporary model can be generated so that we can view the rough sketch and improve upon it.

The last step in the process is the exporting of the model to the connected application – SketchFab. As long as the connection is stable and the quality of photos is of the necessary level, the generated object will be of sufficient quality for educational purposes.

It should be noted that the entire process of capturing photos that are send to the cloud and the feedback returned from the cloud to the mobile device, consumes an amount of data that is currently in the volume of one to two gigabytes. There are variations depending on the quality of the camera of the mobile device, as well as the work area in which the object is being captured, and whether it has been cropped or not. After testing, our best results were obtained using a small work area, using an object that has fewer edges, in a single session. The camera quality of an IPhone 10 is sufficient for our case for education purposes.

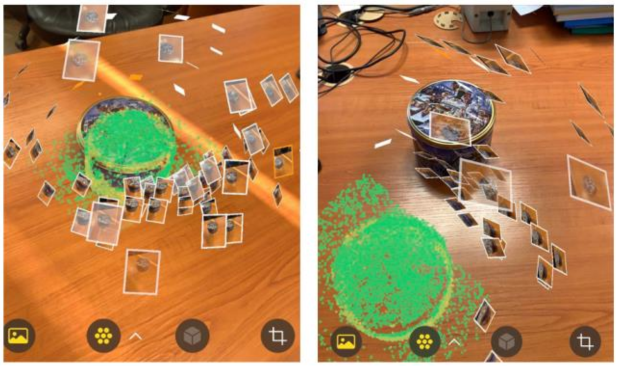

Figure 5. Comparison between the different sessions and the issues with centering the object and its' recognition points

Several difficulties that have been found during the process include correct use of the session functionality of the app. Experiments showed that it is cumbersome to find proper alignment of the object during the subsequent sessions. After the first scan is complete, the images are uploaded to the cloud and an object is generated, the data for the mobile devices' position is lost. A small task about sessions will be included in the students' workshop so that they can also experience the limitations of the software. The problem can be seen on Figure 5. The misalignment between the object in the first session and its virtual representation in the second session is obvious. A prompt centers the work area again, but it is difficult to continue the process without errors. It is meaningful to show the students the current drawbacks in positioning the camera.

E. Advantages and disadvantages in using AR in education

Based on our experience with working with AR in higher education, we have confirmed the benefits and drawbacks of using it for educational purposes.

The wide use of digital assets as well as the dynamics of students' working and living environment reflect the necessities of contemporary learners. We are currently facing a situation of continual search for possibilities for training options beyond traditional classroom approaches. Learners are connected to the virtual world by means of the Internet and their smartphones, having to absorb an enormous amount of data online. Information technologies provide learners with the ability to purposely collect and synthesize data extracted from different sources in a short amount of time [12].

Many educational institutions have realized the need to improve the learning process using AR technology. Some of the most outstanding advantages are the interactive learning process, the heightened student engagement, the transformation of study materials, and the enhancement of distance learning. From an e-learning and student-centered aspect, the key benefits of using AR include support of kinesthetic (tactile) learning, collaborative learning, distance/remote learning, learner-centered learning and creative learning [13].

As AR is a relatively new and developing technology, it introduces difficulties when educators have to operate using it. It must be noted that it has the same disadvantages of any new technology – adoption is difficult, as it is constantly evolving, improving, and changing, but with the development of applications like RealityScan, the process of including it in the classroom should become more streamlined and accessible to everyone.

Another challenge that has to be mentioned is that from the social aspect, the usage of AR can lead to isolation and undermine the element of human interaction that is so vital to successful learning environments. This is one of the main factors which prompted the inclusion of teamwork and team projects, which help in that aspect, as students work together solving challenges, communicating and improving both socially and technologically.

III. CONCLUSION

Students have to face the difficulties of operating such software and develop experience, giving them ideas for solutions and improvements, as well as igniting their interest in working with such applications.

The created methodologies strive to enhance student education and their experience with modern technologies – such as AR, virtual environments, 3D modeling and manipulation.

This study gives us the groundwork in order to further our research on the topic and start experiments with students. After all the preliminary work is completed, it is expected that the workshops should flow smoothly and the students will benefit from realizing the classwork goals.

After analyzing and testing the capability of the tools to be used in the classroom in a small test, it has been concluded that they are a viable solution to the problem of introducing and working with AR. More extensive testing with students is required, so that data and feedback can be collected and analyzed, thus improving the process and the methodologies.

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