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3d Models using Photography and Drone in Education (AI-Enhanced Learning)

By Krunoslav Bedi [*] *& Alan Novkinić* [±]

This paper provides a comprehensive overview of the process of creating a 3D model using photography and a drone and its subsequent modification for 3D printing. The process includes data collection with a high-resolution camera and a drone, their processing into a digital 3D model and preparation for 3D printing. To further explore and apply this process in an educational setting, we developed a hands-on method that engages students in the processes of scanning, modeling, and data analysis, thereby encouraging the development of STEM skills. This method involves surveying and calculating certain variables, which allows quantitative monitoring of student progress and technology effectiveness.

Keywords: *3D modeling, AI tools, case study, drones, photogrammetry*

Introduction

In the last decade, technologies such as drones, high-resolution cameras, and 3D modeling have become an indispensable part of various industries, including architecture, engineering, archaeology, and even education. The integration of these technologies into the educational process represents a significant step towards the advancement of STEM skills (science, technology, engineering, and mathematics), which is becoming a priority in modern educational programs around the world. According to Ryu et al. 2020., drones are one of the current new driving forces for economic development. In the context of education, 3D modeling technologies and photogrammetric techniques have enormous potential because they allow students not only to passively learn about objects and spaces but also to actively participate in the process of their digital reconstruction. Drones not only provide new opportunities for data collection in education, but they also encourage student engagement and participation in the learning process. In this context, there is a significant need for a thorough examination of how drones are integrated into current pedagogical practices (Jiang et al. 2024).

Photogrammetry, a technology that uses photographs to measure and create 3D models, combined with drones, provides an efficient and affordable way to collect data. Drones, which are increasingly used in education for their aerial imaging capabilities, provide invaluable assistance in creating precise 3D models. The integration of technology into the curriculum has been shown to improve students' motivation and understanding of complex subjects. According to Abichandani et al. 2024., students perceived the workshops to be a valuable

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experience in their drone industry skills and knowledge, and the use of drones in an educational context enables students to gain practical knowledge and skills necessary for future careers. This approach allows for views from different angles, which makes the models more realistic and detailed, all with relatively simple implementation in educational projects. According to Williams et al. 2023., these results not only validate the utility of drones within a natural resource curriculum but confirm the effectiveness of the methodology in increasing a student's skill level and confidence to complete drone-related projects independently in the future.

The introduction of drones and 3D modeling into education enables the creation of new pedagogical practices that encourage students to develop technical skills, as well as a deeper understanding of geometric and spatial-visual concepts. Technologies such as 3D modeling encourage student engagement and increase their motivation to learn.

This method also enables students to understand complex technical processes, such as scanning, modeling, and preparation for 3D printing, through actual project work. Using drones in education also develops their problem-solving ability and analytical thinking as they are faced with challenges such as controlling devices, processing data, and adapting software to process 3D models. Aerial photogrammetry, when combined with drone technology, offers unprecedented accuracy in capturing 3D data, enabling immersive learning experiences.

In order to quantitatively evaluate the effectiveness of these technological tools, it is important to monitor the progress of students through the different phases of the project, using instruments such as surveys and evaluation of derived models. Systematic monitoring of student progress can provide important information about the effectiveness of technology use in education. Such methods allow monitoring the development of students' skills and understanding, as well as assessing their level of satisfaction with the learning process.

Photogrammetry, using both aerial imagery and terrestrial methods, has emerged as a leading technique for mapping and understanding complex environments, enhancing our ability to create detailed 3D models (Ternon et al. 2022).

This paper aims to demonstrate how the use of photogrammetric methods in combination with drones can be effective in education, especially for the development of STEM skills. It also analyzes students' satisfaction with the use of these technologies, based on their participation in projects that involve the creation of 3D models. Based on the data collected, the paper will demonstrate how such tools can significantly improve educational processes, enabling students to practically apply theoretical concepts and develop the skills necessary for the modern work environment.

Application of the Method in an Educational Context

This method can be implemented in an educational setting through project work that includes theoretical lessons and practical application of what has been learned. Students are actively involved in all phases of creating a 3D model, from data collection to 3D printing, which encourages the development of their technical and analytical skills.

In an educational context, it is important to ensure that teachers have adequate training in the use of these technologies to effectively guide students through the learning process. Teachers need to be trained not only in the technical aspects of drone operation but also in how to integrate these tools into their curriculum to maximize learning outcomes. Also, administrative support in the form of funding and resources for equipment can significantly affect the success of implementing these methods.

In addition, it is crucial to introduce an interdisciplinary approach that connects different subjects such as mathematics and art. Interdisciplinary education enhances students' ability to apply knowledge from various fields, which is essential for tackling complex problems in real-world scenarios. The inclusion of collaborative projects can further enrich the students' experience, encouraging them to solve problems together and exchange ideas.

To assess the effectiveness of this method and the progress of students, it is suggested to use surveys and calculations to monitor their understanding and satisfaction with the process. Some of the key indicators are understanding photogrammetry, drone control, and satisfaction with the final 3D model.

Materials and Methods

Data Collection with Photography and Drones

The process of creating a 3D model begins with collecting photographs of an object using a drone with a high-resolution camera.

- Equipment Preparation: Students learn the basic principles of drone control, as well as the technical aspects of photography, such as shooting angle and resolution.
- Shooting: Students operate the drone to photograph the selected object from different angles, creating a detailed visual representation needed for 3D modeling.

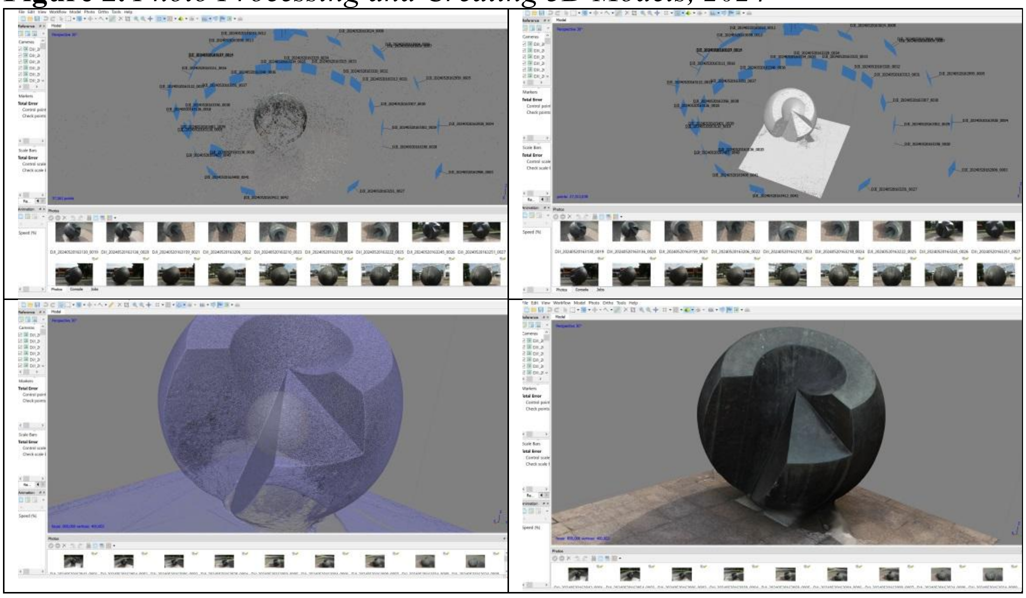
Figure 1. *Data Collection with Photography and Drones*

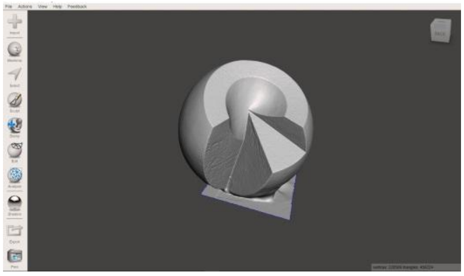
Source: Personal photo gallery, 2024.

After collecting the photographs, the data is entered into photogrammetry software to create a 3D model. After collecting the images, students return to the classroom, where they use software to create 3D models. At this stage, AI tools can be used to analyze the images and provide feedback on the quality of the images. Students are taught how to enter images into the software and how to generate 3D models.

- Software Processing: Students learn how to use software to convert photographs into digital 3D models through the photogrammetry process.
- Mesh creation: The software automatically generates a polygonal mesh, which is then optimized for 3D printing.

Figure 2. *Photo Processing and Creating 3D Models, 2024*




Source: Personal photo gallery, 2024.

Preparing the 3D Model for printing

Students adjust the 3D models to make them suitable for printing on a 3D printer.

- Model optimization: Students check the geometry of the model and fix any errors that could affect the print quality.
- Adjustment: Students adjust the model to ensure stability during 3D printing.

Figure 3. *Preparing the 3D Model for printing*


Source: Personal photo gallery, 2024.

3D printing

Once the model is optimized, the 3D printing process begins.

- Printer setup and parameters: Students learn how to set up the 3D printer, select appropriate materials, and define printing parameters.
- Post-processing: After printing, students perform final work on the model.

Hypotheses:

Students will achieve a high level of satisfaction and understanding of the process of creating a 3D model using photography and a drone after completing the project.

Survey and sample:

The survey was conducted with 40 third and fourth-grade students of the Civil Engineering, Architectural Engineering and Media Engineering majors at the Čakovec School of Architecture.

Survey questions:

1. How familiar were you with the photogrammetry technique before this project? (1 - Never heard of it, 2 - Basic knowledge, 3 - Familiar with the theory, 4 - Experience in the application, 5 - Completely familiar)
2. How challenging was it for you to operate the drone? (1 - Very challenging, 2 - Challenging, 3 - Neutral, 4 - Easy, 5 - Very easy)
3. How would you rate the ease of photographing an object from different angles? (1 - Very difficult, 2 - Difficult, 3 - Neutral, 4 - Easy, 5 - Very easy)
4. How difficult was it for you to use the software for processing photos into a 3D model? (1 - Very difficult, 2 - Difficult, 3 - Neutral, 4 - Easy, 5 - Very easy)
5. How satisfied are you with the final 3D model you created? (1 - Not at all satisfied, 2 - Slightly satisfied, 3 - Neutral, 4 - Satisfied, 5 - Very satisfied)
6. How useful do you think this experience will be for you in the future? (1 - Not at all, 2 - Slightly, 3 - Neutral, 4 - Useful, 5 - Very useful)
7. How involved were you in each part of the process (scanning, data processing, printing)? (1 - Not at all, 2 - Partially, 3 - Neutral, 4 - Involved, 5 - Fully involved)
8. Which part of the project was the most interesting for you? (1 - Drone control, 2 - Photo processing, 3 - 3D model creation, 4 - 3D printing)
9. How satisfied are you with the mentoring and explanations during the project? (1 - Not at all satisfied, 2 - Slightly satisfied, 3 - Neutral, 4 - Satisfied, 5 - Very satisfied)
10. How much do you think you have improved your technical skills through this project? (1 - Not at all, 2 - Slightly, 3 - Neutral, 4 - Improved, 5 - Significantly improved)

Table 1. *Descriptive Statistics*

	Mean	Standard Deviation
Question 1	4.1	1.1
Question 2	2.8	1.2
Question 3	3.6	1.3
Question 4	3.2	0.7
Question 5	4.1	0.8
Question 6	4.2	0.7
Question 7	3.8	0.6
Question 9	4.2	0.8
Question 10	4.0	1.0

Question 8	The most interesting part of the project			
	Drone control	Photo editing	3D model creation	3D printing
	12%	32%	36%	20%

Results of the t-test with the new population mean (3.0):

- t-value: $t=4.74$
- p-value: $p=0.0015$

Interpretation:

- The t-value (4.74) indicates that the sample mean (3.78) is significantly higher than the target value (3.0).
- The p-value (0.0015) is much lower than the significance level $\alpha=0.05$

There is a statistically significant difference between the mean student satisfaction score and the target value of 3.0. In other words, students in this sample show significantly higher satisfaction than the 3.0 level.

Conclusion

Based on the results, we determine that students are on average very satisfied with the educational arrangement, which indicates the achievement of the project objectives in terms of quality and satisfaction. However, the results also show that additional attention is needed to improve aspects with lower scores, such as the complexity of using the software or the challenges of controlling the drone. These parts of the project require better-designed approaches, which will allow students to cope with technical challenges more easily, but also to develop their skills in a way that is progressive and gradual.

One of the key elements for improvement in future projects could be to provide additional training and guidance during the phases that have proven to be the most difficult for students. For example, a series of introductory lessons could be designed to introduce students to the basics of 3D modeling software before they start practical work. This will ensure that students have enough theoretical knowledge to feel more confident when working on more complex tasks.

It is also important to provide more opportunities for individualized help and mentoring throughout the project, which can reduce the frustration of students who face technical difficulties. Through regular meetings and consultations with mentors, students can receive personalized advice and solutions to specific problems, which will further increase their motivation and success.

Continuous feedback collection, not only at the end but also throughout the project, will enable better real-time adjustments, ensuring that all parts of the process are equally effective and beneficial for students. In this way, any future project can be improved based on students' direct experiences, thereby increasing the effectiveness of the educational program and contributing to its further development.

In addition, the evaluation of the results must include quantitative and qualitative analyses that will allow for a deeper understanding of specific problems and potentials in the use of technology in education. By using various monitoring methods, including surveys and analysis of generated 3D models, a broader picture can be obtained of how students respond to technology and what adjustments are needed to ensure that all students have the best possible educational experience.

Ultimately, the implementation of these recommendations will enable the creation of an educational process that is flexible, dynamic and able to respond to the different needs of students, ensuring that each student gets the opportunity to develop their skills in a way that is tailored to their abilities and interests.

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