Photogrammetry in 3D Game Development Education: A Case Study of Student Learning

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Abstract. This paper presents a case study on the integration of photogrammetry into undergraduate game development education. Conducted within the course *AD185 – Izrada 3D video igara* at Metropolitan University, the module engaged six students in capturing real-world objects and transforming them into optimized, textured 3D models for use in Unity Game Engine. A mixed-methods approach was employed, combining pre- and post-assignment questionnaires with technical evaluation of the resulting models. The results indicate significant improvements in student understanding, practical skill acquisition, and engagement. The assignment also encouraged students to critically evaluate different workflows, balancing automation and manual control. Despite a small cohort, the findings suggest photogrammetry is an effective, scalable addition to 3D modeling curricula. The paper concludes with recommendations for implementation and outlines future research directions in photogrammetry-based education.

Keywords: Photogrammetry, 3D Modeling, Game Development Education.

1 Introduction

Photogrammetry, the process of reconstructing three-dimensional (3D) digital models from photographs, has become an essential technique in the contemporary game development pipeline. By enabling the transformation of real-world objects and environments into textured 3D assets, photogrammetry offers a fast, scalable, and increasingly accurate alternative to manual modeling techniques. As gaming audiences continue to demand photorealistic content, studios have embraced photogrammetry for asset generation, especially in creating environments, props, and surface textures with fine detail and realism [1, 2].

Beyond industry applications, photogrammetry is gaining attention in higher education as a powerful pedagogical tool. In domains ranging from archaeology and cultural heritage to architecture and design, educators are adopting photogrammetric workflows to provide experiential learning opportunities that bridge the digital and physical worlds [3, 4]. These approaches support active learning through direct engagement with spatial data, while also fostering technical and creative skills [5]. The ability to scan real

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objects and process them into game-ready assets offers students immediate feedback and motivation, making photogrammetry a valuable addition to curricula focused on 3D modeling and game development.

Despite the growing relevance of photogrammetry in the digital content creation industry, its integration into game development education remains relatively underexplored in scholarly literature. While there are successful examples of its use in cultural preservation [6], landscape modeling [7], and historical reconstruction [8], few studies have examined how photogrammetry can enhance learning outcomes in game design programs specifically. Moreover, little is known about how students experience the technical and creative challenges of capturing, processing, and integrating photogrammetric models into real-time real-time game engines such as Unity or Unreal.

In this paper, we present a case study from the undergraduate course AD185 “Izrada 3D video igara” (3D Game Development) at Metropolitan University, where a dedicated photogrammetry module was introduced to teach students how to create their own 3D assets from real-world objects. Six students completed the module, including a practical assignment and pre/post questionnaires to evaluate expectations, experiences, and learning outcomes. The goal of this study is twofold: (1) to assess the pedagogical value of photogrammetry in a game development context, and (2) to document student-created models, tools used, and the overall effectiveness of this approach in developing practical skills relevant to digital game production.

2 Related Work

Photogrammetry has undergone significant development in recent decades, emerging as a foundational technique in both industrial and academic contexts. In digital content creation, particularly within the video game industry, photogrammetry allows the efficient and accurate reconstruction of real-world objects and environments for use as digital assets. It is valued for enabling rapid generation of realistic geometry and texture data, thereby shortening development cycles while increasing fidelity [1, 2].

The use of photogrammetry in education has also gained considerable attention. Chapinal-Heras et al. [3] demonstrated the pedagogical potential of photogrammetry in a history curriculum, where students used image-based 3D modeling techniques to digitize cultural artifacts. This hands-on approach helped students better engage with course material while developing transferable technical skills. Similarly, Sapirstein [4] reported on the value of photogrammetry in archaeological education, emphasizing how it enhances students’ spatial reasoning and data literacy through direct interaction with field data.

These findings align with broader efforts to integrate 3D modeling into immersive educational environments. Hughes et al. [5] compared photogrammetry and laser scanning in the context of real-world capture for virtual reality applications, concluding that photogrammetry provided a cost-effective and accessible solution for creating immersive learning assets. Their findings suggest that students benefit not only from acquiring technical competencies but also from applying those skills in multidisciplinary and experiential settings.

In the context of game development, photogrammetry offers an effective bridge between artistic and technical disciplines. Pejić et al. [6], in their study of a historical reconstruction project, compared manual and automatic photogrammetric approaches to model the Barutana building in Serbia. The semi-automatic approach yielded a simplified but manageable model suitable for visualization and presentation, whereas the fully automatic method produced a highly detailed and geometrically accurate model, albeit with a substantially larger file size. Their findings highlighted trade-offs between manual effort and computational complexity, and their conclusions remain relevant to game development workflows, where asset performance and visual fidelity must be balanced.

Further research by Vannini et al. [7] explored photogrammetry's role in landscape modeling, emphasizing its scalability and adaptability to various levels of detail. This is particularly relevant to open-world game environments, where accurate terrain and environmental models are required. Similarly, Koutsoudis et al. [8] conducted a performance evaluation of multi-image 3D reconstruction, concluding that photogrammetry techniques, if properly applied, can deliver high-quality models comparable to those obtained with more expensive methods.

Finally, Guidi et al. [9] and Dall'Asta and Roncella [10] contributed to the methodological literature by analyzing photogrammetric pipeline components, such as image alignment, dense matching, and mesh reconstruction. Their studies underscore the importance of algorithmic selection and parameter tuning, especially when photogrammetry is taught as part of an applied curriculum.

Prior literature illustrates photogrammetry's strong potential to support learning through practice, foster technical skill development, and promote interdisciplinary thinking. However, there remains a gap in empirical studies focusing specifically on photogrammetry in game development education. This paper aims to contribute to this emerging area by evaluating how photogrammetry was introduced in a game design course, what students created, and how their learning evolved through the process.

3 Methodology

3.1 Course Context and Objectives

This study was conducted within the undergraduate course AD185 "Izrada 3D video igara" (3D Game Development) at Metropolitan University. The course is part of the curriculum for students specializing in game design and interactive media and aims to equip them with practical skills in 3D modeling, animation, and game engine integration. The photogrammetry module was introduced mid-semester as an experiential learning intervention, designed to bridge real-world object acquisition with digital asset creation workflows used in the video game industry.

The learning objectives of the photogrammetry module were threefold:

1) introduce students to image-based 3D reconstruction methods and tools,
2) provide practical experience in converting real objects into game assets, and

3) enhance student understanding of the end-to-end digital content creation pipeline, including capture, modeling, optimization, and game engine integration.

3.2 Assignment Design and Workflow

Six students participated in the module. Each was assigned the task of independently selecting a real-world object, capturing a series of photographs from multiple angles, and processing the image set using photogrammetry software. Students were given a choice of both mobile and desktop-based applications, including:

- RealityScan (Epic Games) and Polycam – mobile applications offering guided photo acquisition and automated cloud-based processing,
- Meshroom (AliceVision) – an open-source desktop tool requiring an NVIDIA GPU or the OpenCL variant (MeshroomCL) for AMD systems,
- RealityCapture – a high-end desktop application available via student license.

Students were instructed to photograph their objects in consistent lighting conditions with sufficient overlap between images. The resulting image sets ranged from approximately 20 to 100 photos per student, depending on object size and complexity. Processing was performed either on students' personal devices or remotely via cloud services, yielding textured 3D mesh outputs.

Following reconstruction, students were required to:

- Import the model into Autodesk Maya for cleanup, including removal of background elements, and minor corrections,
- Export the optimized model in a game engine-compatible format,
- Test the model's integration into the Unity engine, including material assignment and scene placement.

Students also documented their workflows and outcomes in a structured report, including technical metadata such as:

- number of images used,
- time required for photography and processing,
- final polygon count,
- file size of the exported model,
- quality and clarity of generated textures,
- and whether further processing in Maya was required.

This documentation was used as the basis for comparative technical analysis.

3.3 Questionnaire Design and Data Collection

To evaluate the learning impact of the module, students completed two anonymous questionnaires: one prior to the assignment (pre-questionnaire) and one after completion (post-questionnaire). The pre-questionnaire assessed students' baseline knowledge and expectations, including questions such as:

- "Have you previously heard of or used photogrammetry?"
- "What challenges do you anticipate in capturing or processing real-world objects?"

The post-questionnaire measured shifts in perception and self-assessed learning outcomes, using both Likert-scale items and open-ended questions, such as:

- How would you rate understanding of photogrammetry after the assignment?
- What was the most challenging part of the process?
- Would you consider using photogrammetry in future? Why or why not?

Responses were coded and analyzed thematically to identify common experiences and emergent learning patterns. By combining quantitative data from model outputs and qualitative data from student reflections, this study employed a mixed-methods case study design, enabling a holistic assessment of both technical proficiency and perceived educational value.

4 Results

This section presents the outcomes of the photogrammetry module in terms of student feedback, learning progression, and technical characteristics of the generated 3D models. Results are derived from both the questionnaires and the technical evaluation of the submitted assignments.

4.1 Student Feedback and Learning Outcomes

Pre-assignment awareness and expectations. Prior to the module, only 2 out of 6 students had heard of photogrammetry, and none had previously used it in any form. Most expected the process to be either "highly technical" or "difficult to manage without professional equipment." On a 5-point Likert scale (1 = no knowledge, 5 = expert knowledge), the average self-assessed understanding of photogrammetry was **1.8**.

Post-assignment reflections. After completing the assignment, students reported a significant increase in understanding, with the average self-assessment rising to **4.0**. All students rated the experience as "valuable" or "very valuable," and five out of six stated that they would consider using photogrammetry in their future projects. Open-ended responses highlighted several recurring themes:

- **Realism and satisfaction**: "It was amazing to see how real the object looked in Unity with real textures."
- **Technical challenge**: "Lighting was tricky; I had to redo the photo session twice."
- **Learning motivation**: "I want to try scanning larger scenes next."

The post-questionnaire also revealed an increased confidence in using new tools and integrating external workflows into the game development process.

Perceived challenges. Students identified three main challenges during the assignment:

1. Ensuring sufficient photo coverage to avoid holes in the mesh.
2. Managing lighting conditions and surface reflectivity.
3. Processing time and system requirements, especially when using desktop software.

Despite these difficulties, all students completed the assignment successfully and gained practical insight into both the benefits and limitations of photogrammetry.

4.2 Technical Evaluation of Models

Each student submitted a complete asset pipeline: image set, reconstructed mesh, cleaned model, and Unity-integrated prefab. A summary of the technical data is provided in Table 1.

Table 1. Technical Summary of Student Photogrammetry Projects

Student	Object	Photos	Software	Triangles	Size (MB)	Time (Min)
Veljko Kovacevic	Statue	58	Meshroom	176,574	99.4	85
Luka Kurtic	Statue	100	RealityScan	7.955	1.4	20
Luka Rankovic	Chair	45	RealityScan	99,993	15	17
Lazar Stanisavljevic	Bottle	20	RealityScan	1,000,008	32	30
Dimitrije Stojanovic	Slipper	30	Polycam	13,390	3	12
Milos Nikolic	Bike	100	RealityCapture	256,453	143	254

Across all projects, texture quality was generally strong due to the use of real surface photography. Polygon counts varied based on software and optimization (Figure 1). Students using mobile applications produced lower-poly models by default, while those using desktop tools (e.g., Meshroom) submitted higher-resolution meshes, which required manual decimation in Maya to be suitable for game engines.

Fig. 1. 3D models created by students using photogrammetry method

5 Discussion

The results of this study provide meaningful insights into the integration of photogrammetry into a game development curriculum. Both the qualitative and quantitative outcomes confirm that photogrammetry not only enhances technical proficiency but also promotes creativity, engagement, and interdisciplinary thinking among students.

5.1 Educational Value and Skill Development

One of the most notable outcomes was the increase in students' confidence and competence in working with unfamiliar digital tools. The shift in self-assessed knowledge from an average of 1.8 to 4.0 on a 5-point scale, demonstrates that even a short, well-structured module can significantly enhance student understanding. This aligns with findings from other studies [3, 4], which emphasize that experiential engagement with photogrammetry enhances spatial reasoning and procedural knowledge.

In this module, students did not merely follow a theoretical introduction but engaged directly in the complete asset pipeline, from data acquisition to deployment in a real-time game engine. This approach reinforced applied knowledge and mirrored real-world workflows in game studios [1, 2], validating the pedagogical decision to integrate photogrammetry as a hands-on, project-based learning experience.

5.2 Tool Selection and Workflow Comparison

Students used a variety of software tools depending on hardware availability and personal preference, resulting in a natural comparison between mobile-based and desktop-based workflows. Those using mobile apps like RealityScan or Polycam benefited from faster, more automated pipelines but often faced limitations in texture sharpness and mesh optimization. In contrast, desktop tools like Meshroom and RealityCapture offered higher accuracy and control at the cost of increased complexity and processing time.

This distinction parallels findings in professional and academic literature [6, 10], which show that automatic photogrammetry solutions prioritize accessibility and speed, whereas semi-automatic or manual workflows, though more labor-intensive—allow for better customization and asset fidelity. Within the classroom context, both approaches proved pedagogically valuable: mobile apps lowered the barrier to entry, while desktop solutions challenged students to refine their technical workflows and practice digital cleanup and optimization.

5.3 Trade-offs: Accuracy vs. Efficiency

The technical results revealed substantial variance in polygon counts and model sizes (from under 10,000 to over 1 million triangles), depending on the reconstruction method and user intervention. Students who spent more time optimizing their models, either by cropping extraneous geometry or decimating dense meshes, produced assets that were both game-engine ready and aesthetically compelling. This highlighted the importance of balancing visual realism with performance constraints, a fundamental concern in game development [5, 7].

The assignment fostered awareness of data integrity and artifact correction. For example, students who failed to capture the underside of an object or used inconsistent lighting learned firsthand how incomplete data affects model quality. These real-world challenges taught students critical lessons in planning and executing digital capture, mirroring the practical difficulties encountered by professionals in the field [9].

5.4 Student Engagement and Motivation

From a motivational perspective, the project format proved highly effective. Students frequently expressed enthusiasm for the tangible nature of the task, photographing real-world objects and seeing them appear, realistically textured, within a game engine. This tangible transformation from physical to digital fostered a sense of accomplishment and ownership, echoing observations from other pedagogical studies that highlight the power of hands-on digital fabrication to increase engagement [3, 8].

The open-ended nature of the assignment encouraged creativity. Students selected personally meaningful objects, from statues and bikes to bottles and furniture, resulting in a diverse and culturally resonant portfolio of models. This individualized approach promoted intrinsic motivation and made the technical learning process more relatable and enjoyable.

6 Conclusion

This study demonstrated the successful integration of photogrammetry into an undergraduate game development course, where students created game-ready 3D models from real-world objects. Through a structured assignment involving image capture, 3D reconstruction, and game engine integration, students acquired essential technical skills while gaining insight into realistic asset pipelines used in the industry.

The module proved effective in increasing both student engagement and understanding of key concepts such as mesh optimization, texture fidelity, and tool interoperability. Variations in workflows—between mobile and desktop tools—provided a practical lens through which students evaluated the trade-offs between automation and control.
However, the study had limitations, including a small sample size and short duration. Technical barriers such as hardware requirements and software compatibility also posed challenges. Future implementations should incorporate peer feedback, structured performance evaluation, and more advanced topics like environment-scale scanning or error quantification.

Future research should explore longitudinal effects of photogrammetry training, its integration into full game development pipelines, and its value in multidisciplinary collaborations, particularly in design, heritage, and AR/VR applications.

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