Re-envisioning Field Surveying as an Immersive Gamification Experience.

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Abstract. Recent strides in immersive technologies, coupled with advancements in game development, are reshaping engineering education, and revolutionizing the design and delivery of both in-class and lab activities. Traditional experiential practices in field surveying and mapping, which have historically relied on hands-on learning alongside theory concepts, have been supplemented by innovative pedagogical approaches, catalyzed by the disruptions caused by COVID-19. There has been a growing imperative to create virtual and immersive resources and shift towards virtual-based lab designs. In response to this evolving landscape, we present a novel approach that provides students with high-quality field training through an immersive virtual experience. We introduce an interactive web application for topographic surveying, embedded within a gamification framework, utilizing digital twins to recreate the field space. Our research offers compelling evidence that this approach effectively supports practical training, as demonstrated by real-world use cases conducted in the lab setting. Additionally, we gauge the framework's usability using the System Usability Scale (SUS), affirming its effectiveness as a tool in virtualizing field practice.

Keywords: Field Surveying, Gamification, Virtual Environment, Digital Twins, Experiential Learning, Engineering Education.

1 Introduction

New advancements in virtual and augmented reality and game development revitalize engineering education and the way in-class and lab activities have been designed and delivered [26]. Experiential practice in field surveying and mapping concepts and techniques has traditionally been considered hands-on, in conjunction with classroom practices, to help students understand positioning, mapping, property boundaries surveying, and design layout in the field. This practice of experiential activity allows the students to experience their learning first-hand and then reflect on that experience to develop a new set of skills about the concept they are learning. Traditionally, topographic surveying involved working with modern and expensive instruments and considerable outdoor experiential lab components that provide students with hands-on experience with data col- lection. However, there are several important challenges such as cancellations due to weather, labs are often conducted in the same location, and students cannot build skills that surveyors need in the field with instruments [6]. Hence, having an alternative, accessible, and approachable learning strategy to remove these barriers and prepare students before going on the field was emergent. Furthermore, with the COVID-19 pandemic disrupting these traditional activities in combination with institutional and government-level interventions, there has been a shift to remote learning, effectively losing the opportunity for many educational in-field learning activities. To deal with this, pedagogical innovation in conjunction with advancements of technologies have emerged, and there have been pressures to create more virtual and immersive resources and move to additional virtual-based and immersive lab space design. However, providing this digital lab transformation and experience led to a series of shortcomings. Replacing real-world fieldwork became challenging or nearly impossible for certain fields, such as field surveying where both the physical world and human interaction with instruments are necessary.

On the other hand, immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) play vital roles in providing such experiential education [6]. However, barriers around VR such as nausea and motion sickness limit the overall extensive usage of the technology [5]. The factors of familiarization with technologies as well as the availability of modern devices equally impact the technological adaptation in digital experiential education [6]. For a better and more generic learning experience, a more inclusive and immersive of such extensive applications can be applied to overcome such challenges where the users are not obliged to have sophisticated devices or certain mastery in gaming and VR.

This paper is centered around leveraging immersive digital experiences to digitize and virtualize traditional field spaces in surveying, while also enhancing virtual education engagement within this domain. The concept of Digital Twins, which involves creating virtual models of physical assets and systems using real-time data for simulation and analysis, serves as a foundational element in our approach. Our proposal aims to provide high-quality field training experiences to students by immersing them in a virtual environment through an interactive web application designed for topographic surveying, framed within a gamification context. Our approach represents a novel effort, offering simulated fieldwork experiences for land surveying as a virtual reality, complete with various virtual field scenes and digital twins of the University Campus. Importantly, it captures and enhances the educational outcomes of the course. Through user feedback and observations, we have established that this approach not only offers usability but also serves as a valuable tool in land surveying pedagogy. We present evidence demonstrating the effectiveness of our proposed approach through real-world use cases within the classroom setting. Additionally, we gauge the framework's usability using established metrics such as the System Usability Scale (SUS) [7], further validating its effectiveness as a tool in virtualizing field practice.

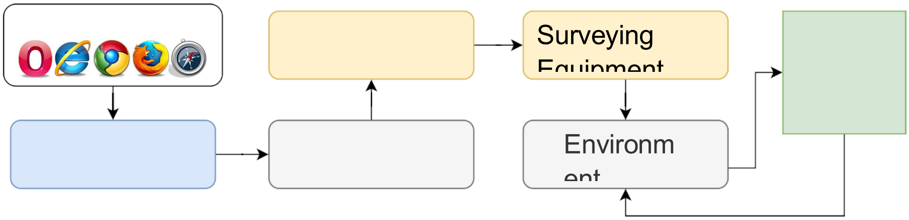

Figure 1. The workflow of the gamification approach for topographic surveying.

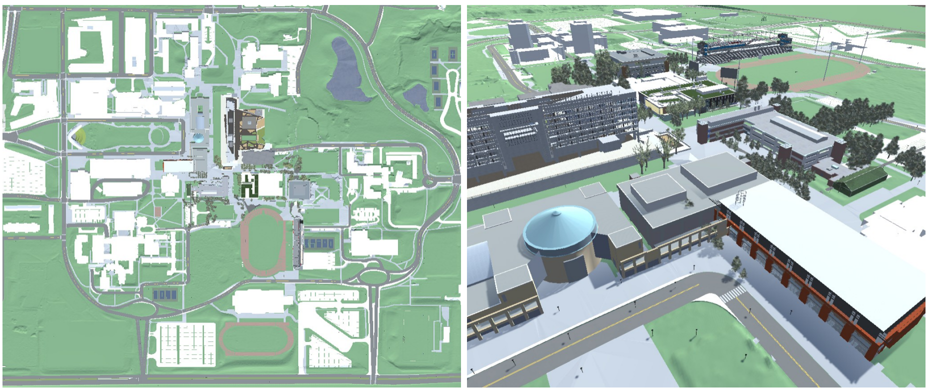

Figure 2. The top-down (Left) and the perspective (Right) view of the 3D BIM models of the campus buildings in the virtual environment.

2 Related Work

Experiential Learning is an engaging learning process, where students learn through doing in the lab, fieldwork, internship, etc. Experiential Learning is rooted by David Kolb. Kolb's Experiential Learning Cycle includes concrete experience, reflective observation, abstract conceptualization, and active experimentation [16]. Experiential learning with immersive technologies refers to the use of virtual reality (VR), augmented reality (AR), and other forms of immersive technology to create learning experiences that allow users to actively engage with and manipulate digital contents. It has been shown to be effective in a range of educational contexts, including science, technology, engineering, and math (STEM) fields, as well as for professional development and skills training [4,6,26]. Such technologies not just provide an extensive set of gamification tools for enhanced education delivery, but also enable virtual platform substantiating experiential learning. The usage of such immersive technology unlocks a virtual space to provide hard-to-grasp ideas and concepts brought in the form of digital reality, that is more understandable, interactive, and fairly flexible.

Due to the global pandemic and the huge shift towards online education, many institutes and educators have been adapting towards enhanced learning experiences using state-of-the-art available tools and technologies to enhance the learning processes and well-being of students [9]. Providing engineering education supported with enhanced digital and interactive learning techniques such as gamification or immersive environments is a fairly new technique to online education system [17,26].

2.1 Experiential Learning with Immersive Technologies for Field Surveying

Virtual reality has been used in the past for surveying purposes, only leveling techniques, primarily in desktop-based implementations [10]. While these methods have some benefits, such as allowing for learning basic surveying principles, they also have limitations. Using a keyboard and mouse for navigation and interaction with virtual instruments can be difficult and impractical, and rendering a 3D environment in 2D can make it hard to fully understand and make decisions based on terrain conditions. To address these issues, some surveying educators have turned to immersive virtual reality [19,18,4], which allows for more natural interactions, navigation, and recreation of physical exercises. The work in [6] compares the use of two approaches, a web-based game, and virtual reality, for virtualizing experiential education and delivering field training to engineering students. The authors compared the advantages and disadvantages of these two approaches and discussed the potential for an integrated implementation in the future. However, these virtual implementations can be costly, requiring a high-end gaming computer and VR hardware. An alternative approach [18] is using mobile virtual reality, which is more cost-effective but sacrifices some realism and requires simplifications.

2.1 Experiential Learning with Immersive Technologies in Other Areas

Shen et al. [25] presented an educational VR training system for teaching marine engineering stu- dents. The system uses optimization methods to improve the fluency and loading speed of the virtual engine room model and includes reasonable human-machine interaction and auxiliary learning and training tools. The work in [14] presented two VR learning systems for use in rock engineering, geology, and mining education. The authors found that training in VR can reduce scatter in measured learning outcomes and increase active learning time by 50%. The "scatter" in learning outcome refers to the degree of variability or dispersion in the performance of learners on a specific assessment or set of assessments. It indicates how widely spread or diverse the scores or achievements of individual learners are across a particular learning outcome. Brandon et al. presented a web-based gamification framework for understanding real-world scenarios such as crowd-sourced design collaboration in a virtual environment [12]. Experiential learning in immersive environments has also been investigated for tourism [24], and pharmacy [15] education. While the use of these technologies is still in the early stages, there is potential for them to revolutionize the way education is delivered and make learning more interactive, engaging, and effective.

Outdoor Park *Urban Area* *Indoor Environment*

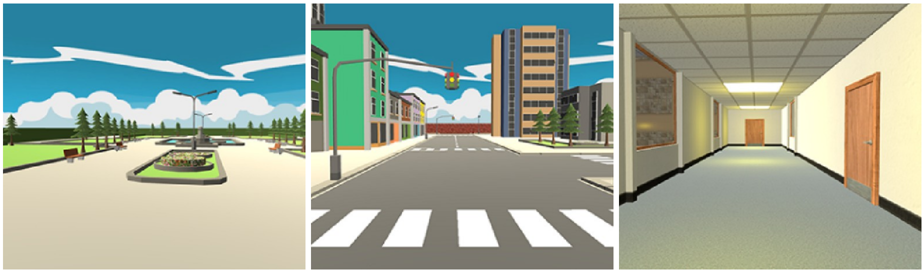

Figure 3. The three computer-generated virtual environments: (left) an outdoor park, (middle) an urban area, and (right) an indoor environment respectively.

3 Methodology

This section presents the proposed experiential learning framework, an interactive gamification approach to topographic surveying. In a typical topographic survey, a user performs the surveying task physically in a real-world environment using tools like Total Station, Prism, Poles, and Tripod Stands. However, with the advent of COVID-19 pandemic, physical surveying out in the real world was not an option. With everything moving to the online medium of instruction, performing hands- on land surveying activities was largely unaddressed. This disruption is also struck as an opportunity to develop an interactive virtual learning experience that would allow the users to engage in the surveying activities the same way as they would in the real world.

Figure 4. A sample geodetic control point in a geodetic spatial reference system deployed in a virtual environment.

3.1 Surveying Game Design Framework

The virtual learning experience starts with visiting the surveying game via a web browser. The users are first asked to create their accounts (or log in if they are already registered), so their activities within the online surveying sessions can be recorded and accessed for later use. Students then get involved in an interactive session comprised of multiple steps to complete the topographic surveying, including (i) choosing an avatar (e.g., Male or Female), (ii) Reminder of safety procedure by wearing a safety kit (e.g., safety vest and helmet), and (iii) collecting the surveying equipment (e.g., prisms, pole, tripod, and total station), before they go out in the immersive digital world to start surveying by locating the National Geodetic Survey Control points and conduct measurements.

The proposed gamification framework follows a structured-based game design that is not limited just to a simulated land surveying experience but is also an effective learning tool where students' learning is stimulated through an optimal level of challenges and well-defined instructional procedures. For example, if the students do not correctly perform any of the surveying actions, the game then warns them to repeat the steps involved and correctly perform the required actions. Hence, al- lowing students to reflect on their mistakes and errors as they progress while completing the survey tasks and achieving mastery competencies required for basic and topographic surveying practice. Students can take as many survey measurements as they like, and in the end, they can download all of their recorded surveying measurements as a CSV file to do the post-surveying calculations and mapping. The following subsections provide details on the methodology adopted in the surveying game.

3.2 Environment Specifications

We wanted users (e.g., students) to experience surveying tasks within a range of environments and landscapes with varying elevations. To accomplish this, we implemented three computer-generated (CG) environments (Figure 3) within the preliminary prototype, which sought to replicate real- world scenarios such as an outdoor park, an urban area, and an indoor environment. Each of the CG environments featured areas of differing elevations in order to introduce variety to the surveying tasks.

The previously mentioned environments were met with a high level of approval from the users (e.g., students). In addition, we received valuable feedback from domain experts (e.g., faculty members teaching the topographic surveying course) through informal conversations, suggesting that we consider using a real-world environment (e.g., a virtual 3D model of a university campus) in our efforts. While we had already been considering this possibility, the direct input from domain experts provided us with the motivation to incorporate 3D Building Information Modeling (BIM) models of campus buildings and their outdoor surroundings into the surveying game.

To the best of our knowledge, this marks the first time that 3D BIM models of real-world buildings on a university campus have been introduced in a virtual environment (Figure 2) for the purpose of topographic surveying in the game environment. Furthermore, we have integrated real- world geodetic control points (Figure 4) from the provincial geodetic database [11] throughout the 3D virtual campus Model. A control point is a location with known world coordinates in a defined geodetic spatial reference system.

3.3 Surveying Specifications

We designed surveying game specifications based on topographic surveying practice which it includes a variety of basic surveying skills from control survey design, distances and angles measurements, positioning of features on the ground in 2D or 3D coordinates, operating total stations, and compu- tation as well as error analysis. The process was scripted by a knowledge domain expert (principal investigator in this paper) and validated by multiple industry professionals. This includes the com- plete surveying workflow – a step-by-step procedure that a user would perform to take surveying measurements to complete topographic surveying to export data from the data collector. Figure 1 shows the workflow diagram for topographic surveying tasks that have been developed in the game.

3.4 3D Models and Graphics

The 3D BIM models of the campus buildings are obtained from the university digital Twins project development working in ISSUM [21] project. After receiving the BIM models, we fine-tuned them in Autodesk Revit [2] (a 3D environment modeling platform used by designers and architects). The 3D models of land surveying equipment (e.g., total station, prisms, pole, and tripod), as well as the safety kit (e.g., safety helmet and vest), are created using 3ds Max [1]. The textures for the 3D models are created using Adobe Photoshop [13] and Blender [22].

Collecting Safety Kit *Collecting Surveying Equipment*

Figure 5. Game screens for picking up and wearing the safety kit (Left) and collecting the surveying equipment (Right).

3.5 Topographic Surveying Game Development

We used Unity3D (Unity Real-Time Development Platform) (Reference x), a 3D game development platform, to design a web-based interactive virtual experience for topographic surveying (Figure 6). We anticipate that the accessibility and platform independence of web apps would allow students to engage with the topographic surveying simulation regardless of their individual technological setups. This inclusivity ensures that a wide range of students can participate in the virtual learning experience. Furthermore, we expect that the collaborative and interactive nature of the web app, combined with gamification elements, would enhance student engagement and motivation. The real- time updates and scalability of web apps were likely seen as advantageous for accommodating a large number of students while maintaining a seamless learning experience.

Figure 6. A snapshot of the game where user is taking measurements for the surveying task.

The steps in the surveying workflow are implemented as game scenes. The game automatic- ally takes users from one scene to another following the transition as it happens in the surveying workflow. When a user goes to the game webpage from the browser, the user is first taken to a login screen for registering with the game. All the users who are already registered can simply login to the game. This is so the users' activities and surveying measurements within a gaming session can be recorded and accessed for later use. The rest of the gameplay is as follows: after registering with the game, the gameplay first takes the user to a safety equipment room to wear the safety kit (e.g., safety helmet and vest) (Figure 5 – Left), then to the equipment area to pick up the required surveying tools (e.g., total station, prism pole, and tripod stand) (Figure 5 – Right). Then comes an avatar selection screen where the user can select a Male or Female avatar for himself or herself. This is to make the gamification experience more personal to the user. Following this, the user is taken to an environment selection screen where from a list of given environments, the user picks the one he/she wants to go into for completing surveying tasks.

One of the main focuses of this work is to create a realistic surveying experience, and therefore, we matched the same level of details and steps in our gamified platform as users experience and are involved in real-world surveying. A first-person controller (FPS) is used as a means for the users to interact in the virtual land surveying. The game allows the users to carry out a set of actions in the virtual field, including walking around in the virtual environment, installing and uninstalling the surveying equipment on the ground, adjusting height for the total station, tripod stand, and prism pole, and taking measurements (e.g., distance and angle between the reference point and surveying points).

To further enhance the user experience, we rendered a laser beam from the center of the lens of the total station to the center of the prism pole. The laser beam changes its color (e.g., green to red) if any object obstructs that line of sight. This is so the users can observe a clear line of sight between the total station and the pole. The game allows users to interact with the environment and the UI using the mouse and keyboard. Users can take as many measurements as they would like while completing a survey task, and at the end, they can download all of their recorded surveying measurements as a CSV file to perform the post-surveying calculations and mapping.

4 Experiments and Results

4.1 Adopting Surveying Game in the Classroom

The developed game was adopted in 2000-level Surveying course since April 2020 (2020, 2021, 2022, 2023) providing students to explore and test the theoretical knowledge that they perceived through lectures and assignments. Traditionally, this course provides fundamental concepts in land surveying where students obtain extensive hands-on experience in the use of land surveying instruments and in the essentials of survey practice in Civil engineering. Pre-Covid the course was designed as an intensive 2 weeks course including weekends from 8:30 am to 5:00 pm. There was a daily 2 hours of face to face lecture focusing on theory and fundamental concepts of surveying techniques following 1-hour tutorial with a focus on calculation and fieldwork procedures in the morning and 4 hours of daily fieldwork in the afternoon where students apply the knowledge and skill they gained through the daily lectures and tutorials. Since April 2020, this is transformed into a remote and online course in 2020, and remote and online course with two days of optional in-person field activities in 2021, and a flipped and in-person hybrid course since 2022 (Figure 7). The hybrid classroom constitutes in-person physical room connecting with a camera, microphone, speakers, and one or multiple screens to an online platform (e.g., Zoom). Where the instructor is in class and students can choose either mode of delivery. Students from in-class and online platforms can constantly interact with each other via online platform activity boards either in class or online. Due to the availability of sophisticated video equipment in the room for streaming online, the lessons can be recorded and captured with high quality. This opens up an alternative learning opportunity for students to connect with the class, instructor, and their classmates from anywhere. Also, students have the opportunity to go back to recording and rewatch the segment of the lesson they struggle with the most and review the materials more efficiently [8][20].

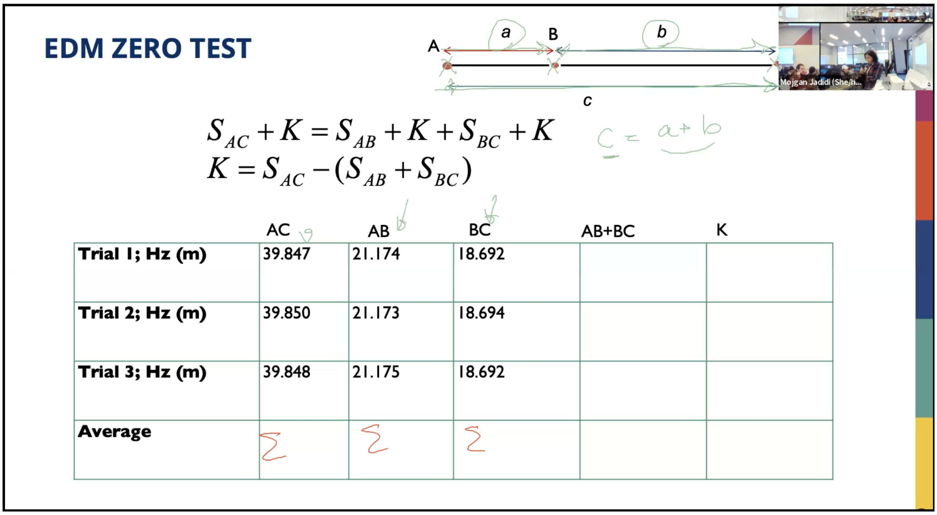

Figure 7. A snapshot of the hybrid classroom setup. The physical room is connected with a camera, microphone, speakers, and one or multiple screens to an online platform (e.g., Zoom). The instructor is present in-person in the class and students can choose either mode of delivery (e.g., in-class or online).

A video demo on how to play the game was given to students before the activity. Students are engaged with the game through a learning journey experience as follows: Before Game Activity: Planning; During Game Activity: Playing Virtual Topographic Surveying; and After Game Activity: Reflection.

Before Game Activity: Planning. Since planning is a key part of surveying practice, students are required to write down the procedural steps to conduct topographic surveying that they have learned. In this step, students are being challenged to think, connect with theoretical contents and cumulative skill sets, and plan the workflow to perform a complete topographic surveying activity. This includes 20% of the project mark.

During Game Activity: Virtual Topographic Surveying. Students are invited to access to the game environment, familiar with the environment, review the planning list from the previous phase, select their area of interest, Identify their design control survey network points, Survey the topographic features by setting up instruments e.g., total station, adjusting the height to get the comfortable position based on their own height, setting up the back-sight to the neighboring control point, setting up prism rod on selected feature boundary until the footprint or eye-view of the selected feature are fully covered, Export the surveyed data as CSV file same as exporting from data collector on the field, perform the calculation and derived the coordinates of surveyed features in the identified spatial reference system, and finally using a drawing tool (e.g. civil3D, AutoCad, or ArcGIS Pro) prepare the topographic map. All these include 60% of the project mark. Students are asked to measure the horizontal angle, vertical angle, and slope distance as well as keep a record of instrument and target heights. This will lead them to calculate the coordinates of selected features and compare their calculated result with X,Y, Z coordinates given by the virtual total station. Then, they are asked to find out the discrepancy between the values and discuss why.

After Game Activity: Reflection. In the last phase, students are asked to reflect on their experience in the game environment compared with the Phase I planning list following the Situation, Affect, Implications, and Decision (SAID) approach, in which students are provoked to reflect on the contents, their game experience, and post-processing actively. This includes 20% of the project mark. The details of each scenario are explained as follows:

- *Situation:* Describe your experience performing topographic surveying in the virtual game environment.
- *Affect:* Describe how you did things differently or similarly to what you thought before in Phase I.
- *Implications:* What happened that you expected or didn't expect and how was that related to how you felt before in terms of the topographic surveying process?
- *Decision:* What are you going to do differently next time confronted with the same situation (e.g. being in the field)? Also explain, what considerations you had to have at each stage of the process to collect the high-quality data.

In 2020, the topographic surveying virtual experience was offered at the end of class and the final project was to a class of 65 students. There was no follow-up in-person field activities to assess students' knowledge due to pandemic restriction. However, in 2021, this experience was introduced right after the topographic surveying and mapping was introduced on Day 6 to a class of 85 students as a virtual field experience followed by an optional in-person field activity on Day 7, where students were able to test their skills that gained via the game too. About 40 students attended two days of in-person field activities. In the summer of 2022 and 2023, there were mandatory daily field activities, where all students had both virtual game and field experience. Figure 8 shows a participant interacting with the online surveying game.

4.2 User Experience Feedback and Observations

The virtual surveying game was used by both novice surveyors (about 350 students) and expert surveyors (about 20 faculty members, professional surveyors, and teaching assistants). Since the developed game is a web-based platform, there is no complaint in terms of computer deficiency or connection failures. In general, there is strong agreement with both novice and expert users in the usability and helpfulness of the surveying game to understand or review the process of surveying, learning from mistakes via the warning system provided through the game, and more confident to work in the field although the lack of working with the instrument is still there.

Additionally, following the SAID approach for students' assessment provides a learning journey to them reflect and self-assessing their skill set and theoretical understanding without being worried about the grades. Having opportunities to re-do the surveying over and over until they feel com- fortable was another benefit of the virtual environment, often this is not the case in real field work due to time constraints and the rigid structure of courses. A preliminary analysis of SAID-based reflections, reveals the fact that most users are enjoying the “game” experience, however, concerned about how to work with instruments and setups in real-life “station setup”, as presented by top 15 words used in students’ report analysis, see (Figure 9).

Figure 8. Snapshots of a participant interacting with the online surveying game.

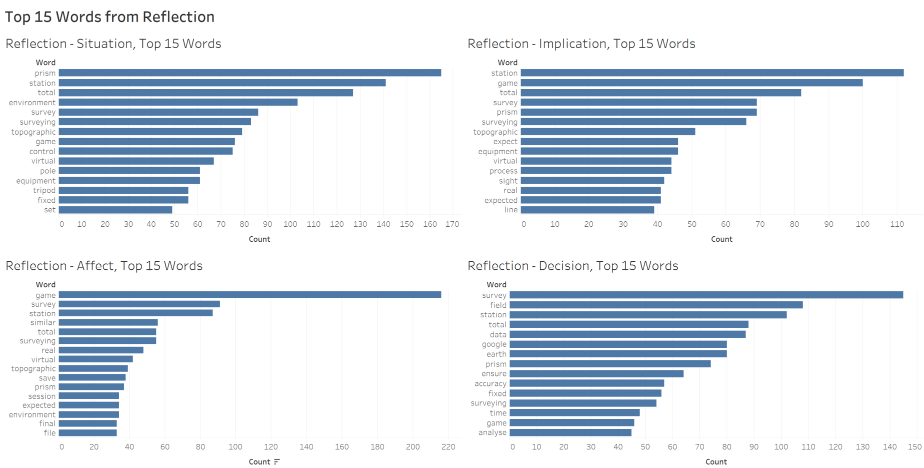

Figure 9. A summary of most frequent words used in reflection reports.

There are strong correlation between “surveying + game”, “total+ station”, “prism + Pole”, “line + sight”, “virtual + field”, “control + survey”, “accuracy + ensure +

prism" words (Figure 9). This deliberates that the users connect their theoretical knowledge with the game environment, seeking to gain skills and perfectionism as well as mastering for next step "going on the field". To have a complete understanding of user experience, detailed survey questions are designed and waiting for approval to distribute among users. The summary of survey questions is provided in Table 1.
We are seeking to get constructive feedback and suggestions to improve the next version of the game and provide an inclusive, equitable, and diverse learning opportunity. With the application being built using Unity Game Engine as well the nature of the application being graphically intensive on computers, we are seeking to learn how varying computers, such as laptops, desktops, and tablets, perform while running the web application. Our survey questions target the research into CPU performance as well as user experience. With the launch of the survey, We are anticipating learning how easy it is for users at the University level to navigate through the varying menu options, make use of provided functions and tools, as well as view the different 3D virtual environments made available in the current version of the game specifically the 3D model of University Campus.
The collected feedback and observations by instructors in the past two years confirm that stu- dents are able to learn and gain surveying skills, this was confirmed by two days of person field activities in 2021. In 2021,2022,2023 experiments, students were more confident to start surveying on the field with more confidence, knowing how to do it, and asking more elaborating and deeper questions, while in the past few first hours or even days spent just explaining the simple procedures.

4.3 System Usability

The System Usability Survey (SUS) [7] is a widely used questionnaire-based assessment tool de- signed to measure the perceived usability of a system. It comprises a set of standardized items that participants respond to on a Likert-scale, generating a quantitative score that indicates the overall usability of the evaluated entity. In the context of evaluating a tool, employing the SUS offers several advantages. Firstly, it provides a structured and standardized approach to assess user perceptions of usability, ensuring consistency in data collection. Secondly, the SUS yields a numerical score that quantifies the perceived usability, enabling easy comparison across different tools or versions of the same tool. This facilitates objective evaluation and enables practitioners to identify areas for improvement.

We conducted a system usability study where we asked the users to complete a SUS questionnaire after playing the surveying game for 10 minutes. Users were asked to perform land surveying measurements in any of their two preferred virtual environments. Right after the users completed the surveying tasks, they were given a SUS questionnaire to complete.

Table 1. Sample Questions for user experience survey using virtual surveying game.

Q1 How was your experience navigating through the user interface? Q2 Did you find it easy to locate the various tools, steps, and instruments?

Q3 How long did it take for you to complete the topographic surveying activity via game?

Q4 Did you find it difficult to identify the control survey points?

Q5 Did you learn something new after using the Virtual surveying game?

Q6 Do you think more virtual Environment representations need to be added in order to visualize the surveying practice in different situations?

Q7 Does your machine experience performance issues when running the Virtual Surveying game?

Q8 Did your machine freeze when running the Virtual Surveying Game?

Q9 Would you like to use the Surveying Game in other courses?

Q10 Would you like to have other surveying practices such as route surveying or building surveying?

Q11 Would you recommend the Virtual Surveying Game to your friends to practice their surveying skills?

Q12 What changes do you think can be made to improve (i.e. new features) in the Virtual Surveying Game?

Table 2. Summary statistics for SUS results, where the score range is from 0 to 100.

Count	Mean	Median	Standard Deviation
15	71.83	75	16.07

Table 3. SUS quartile ranges. The ranges for each quartile of the data are reported to show the distribution of the results. The Interquartile Range (IQR) is also reported.

Quartile	Range
$< Q^1$	25 - 70
$[Q^1, Q^2]$	70 - 75
$[Q^2, Q^3]$	75 - 80
$> Q^3$	80 - 92.5
IQR	9.25

We reported the summary statistics of the SUS scores in Table 2. The quartile ranges for the SUS scores are also reported in Table 3. The SUS score is a compound measure of usability for a system that has been tested on a variety of tasks and proved to be very robust [23]. Typically, SUS scores are scaled from a range of 0 to 100, with scores equal to or higher than 70 considered above average and acceptable [23]. The results indicate that the mean and median scores for the 15 users fall within the adjective range of "good" and "excellent [3]. In addition to mean and median scores, the quartile ranges >= Q2 show a strong preference for a high SUS score. One can interpret this result as the virtual gamification of topographic surveying is highly usable with a degree of confidence.

5 Discussion

Our instructed-based education game provides a great training opportunity for students to conduct surveying virtually at their own pace, and over and over without time constraints and intimidation. Having the hint warning systems made them follow the best practice of surveying and lean toward knowledge retention and skill development. The current version of the game is for individual players, however, the surveying practice in general is a group activity, which limits students' imagination to mimic the real-world scenario of conducting surveying. This came as one of the shortcomings in students' observation of playing the game. In the future, we will add multiple functions to the game where two or more team students can tag along and conduct surveying virtually likewise doing on the field. In order to keep the spirit of teamwork, in the assessment, we asked a group of students to work together, each selecting part of the scene with overlapping areas, and then combining their collected data in computation and CAD drafting steps. The main contribution of this paper highlights providing a hybrid learning environment and alternative mode deliveries provides students more opportunities to study and practice at their own pace instead of traditional learning setups. This was significantly shown by their performance in the field and formative assessments. Students in 2021, 2022, and 2023 were more confident in knowing what to do on the field compared to pre- COVID based on instructor observation and teaching assistant debrief. Often they miss some part of learning outcomes for any reason on the field or in-person class since there is no recording of such moments or virtual space to go and check their skill and knowledge, they tend to struggle in formative assessment. The current surveying class setups (flipped lectures, hybrid in-class time, hybrid lab including this game and field work) have been received overwhelmingly positively by students as indicated in their final grades.

6 Conclusions

This paper highlights the need and potential of coupling game and immersive technologies with engineering education specifically the fieldwork is extensive, experiential, and sometimes daunting or impossible to access. The development of the topographic surveying game, initially conceived as a response to the challenges posed by the pandemic, has yielded substantial insights from experiments conducted in 2020 – 2023.

The key observations converge on a compelling conclusion: the game serves as an invaluable preparatory tool for novice students, especially in the post-Covid era. It significantly enhances their comfort and practical proficiency in fieldwork, while recognizing that mastery of instrument usage ultimately occurs in the physical field setting. By being accessible on the web, the game provides a versatile and inclusive learning environment, free from temporal constraints or the potential intimidation of a peer-surrounded setting. Our hypothesis regarding content retention and enhanced learning outcomes has found validation through the Situation, Affect, Implication, and Decision (SAID) approach text analysis, where students repeatedly cited key learning concepts. Moreover, the System Usability Scale (SUS) results indicated a high degree of confidence that was interpreted as high usability of the developed game. Moving forward, we are committed to an ongoing process of refining the game's design based on user feedback gathered from questionnaires. This iterative approach aims to not only expand the development but also to further evaluate the metrics of success in students' learning journeys.

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