Work-In-Progress: A Scoping Review of Factors Influencing the Success of Digital Games in Engineering Education

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Work-In-Progress: A Scoping Review of Assessment Approaches for Digital Game Implementations in Engineering Education through the Lens of Situated Learning Theory

Introduction and Motivation

Many students entering into our universities today have never seen a time where they did not have access to digital games and apps. This approach to learning has been widespread not only within their educational careers but also in their day to day lives (e.g., loyalty points, fitness trackers, etc.). As a result, many engineering educators have turned to the possibility of implementing games within their classroom, but a critical question remains: How do we measure the success of these implementations? Many game-based learning tools align with key ABET student outcomes, such as teamwork, problem-solving, and effective communication [2]. Not only do these implementations align themselves with ABET outcomes, but in engineering education digital game-based learning can improve both practical and critical thinking, as well as effective communication skills [3]. As digital technologies become more integrated into education, it is important to recognize that single and multiplayer digital games offer distinct opportunities for fostering community, motivation, collaboration, engagement, and problem-solving; often surpassing the capabilities of traditional physical games [4]. However, many studies do not apply standardized assessments for measuring these constructs, as well as other impacts that occur as a result of the game-based implementation in the engineering classroom [5]. Therefore, it can be difficult to ascertain the value of digital game-based learning implementations, limiting their potential adoption in engineering education.

The objective of this study is to identify assessment methodologies that have been used for digital game-based learning implementations within engineering education through the use of a PRISMA flow scoping review (ScR). Through a streamlined 27 step process, this process helps to familiarize reviewers with the dataset, and to allow for replicatability of the review [6]. Additionally, this scoping literature review compares the assessment approaches for how they align with Situated Learning Theory providing a guiding framework to the review process.

Literature Review

Digital game-based learning has undergone increases in implementations over the past 40 years, as evidenced by increases in the proportion of the population engaging with games, with 70-80% of downloaded apps on phones being games [7]. Since 2015, mobile gaming has stayed at a similar level of implementation overall but there have been marked increases in digital gaming with an increase from 51% in 2014 to 75% in 2024 [8]. However, there are still challenges when attempting to implement more complex digital game-based lesson structures in academia, as some learners are not as well associated with the media they are interacting with [9]. This issue was further compounded during the recent Covid-19 pandemic when there was an immediate need to develop digital implementations to provide students with quality remote learning opportunities [10]. These changes attest to the need for analysis of digital game-based learning effectiveness

One of the main reasons for employing digital game-based learning can be motivating students to actively interact with the learning environment [11]. There are many theories that can address student learning potential, however two theories that closely connect with the area of digital game-based learning are Self-Determination Theory (SDT) and Situated Learning Theory (SLT). SDT focuses on the three core psychological needs for growth of an individual as: competence, relatedness, and autonomy [12]. Whereas SLT addresses constructs outside of the level of learning and includes feelings of the individual interacting with the learning environment rather than the environment itself. Analyzing digital game-based learning implementations consistently through a lens that is relatable between studies and covers individual and external potential factors of the implementation is the rationale for why this review chose to frame itself around SLT.

Theoretical Framework

As stated, SLT focuses on the environment surrounding the student and how they learn through four main constructs: Content, Context, Community, and Participation (Figure 1) [13]. Content is defined as presenting the information that is being learned within relatable bounds where students engage in reflective thinking. Context is presented as the "social, psychological, and material environment in which the learner is situated"[14]. Community is made up by the interactions of the individual with others joining practices of analysis and reflection to create shared knowledge experiences. Lastly, participation accounts for how the learners are actively engaged with and interested in the subject or problem that is being discussed. These constructs suggest that most environmental components surrounding a student or learner will affect their learning outcomes. These pillars reflect both active and passive dimensions of learning and extend beyond academic settings to diverse learning environments. Recent research demonstrates SLT's applicability in simulation-based games, where students engage in authentic problem solving scenarios that mirror real world engineering challenges [15].

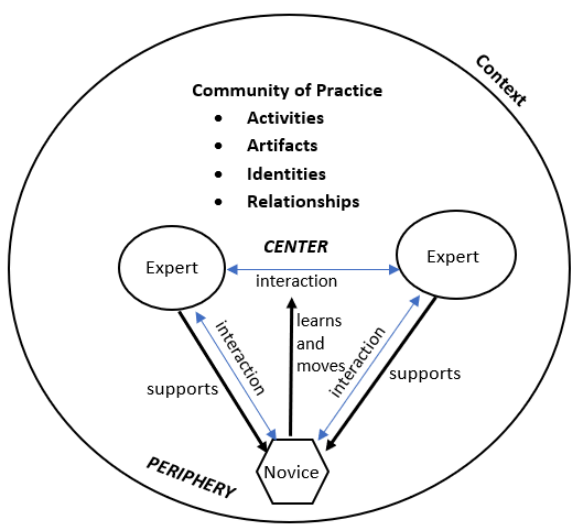

Figure 1. Situated Learning [18]

For the purposes of this study we define the four major pillars of SLT as follows: *Content* accounts for the facts, processes, or skills being learned within the digital game; *Context* is the environment that students are interacting within as part of the implementation (i.e. in the classroom, at home, computer lab on campus, etc.) or a specified setting within the digital implementation (i.e., virtual laboratory, chemical plant, imaginary world); *Community* focuses on the interaction of the individuals engaged with the game both within the game environment (e.g., interactions between both real and characters within game-based learning implements) and external to the game (e.g., interactions across team members); and *Participation* looks at how active students are involved with the learning implementation. Mapping current digital game-based learning assessment strategies to SLT will allow for identification of common elements that are important in game-based learning assessment and could serve as a starting point for development of future standardized assessments.

Focus and Scope

The following research questions are guided by SLT to solidify the objectives of this study:

> Q1. In what ways do current engineering digital game-based learning implementations capture the key constructs of SLT: Content, Context, Community, and Participation?
> Q2. In which elements of the assessment strategy (theory, data collection, and/or data analysis) are the SLT constructs most apparent?

Key features of assessment will be dynamically assessed through the scoping review process. This will allow for identification of key gaps in the literature, understanding of current assessment strategies and their alignment with SLT, and lead to suggestions for standardized assessment strategies for digital game-based learning implementations in engineering education.

Methodology

In order to assess the relevant constructs of Situated Learning Theory across existing digital game-based learning implementation literature, a qualitative scoping review was conducted [16]. Within this methodology, a PRISMA procedure was followed to document the scoping review process along with the justification for our decision making process within the pilot study (Figure 2). For the purpose of this work-in-progress paper, a pilot of the scoping review process was conducted where papers were only collected from Scopus, instead of across multiple databases. To identify potential papers as part of the pilot the search was focused on keywords related to: “Digital games”, “Engineering”, “Engineering education”, and “Digital simulation”, with the search process restricted to returning results from after the year 2016. An example of one search string is shown here: (TITLE ("Gamification" OR "Digital games" OR "simulation" OR "digital experiences") AND TITLE-ABS-KEY (Gamification) AND TITLE-ABS-KEY (Engineering) AND TITLE-ABS-KEY (engineering education) AND TITLE-ABS-KEY ("Digital games" OR "simulation" OR "digital experiences") PUBYEAR > 2016). We specifically focused on only including published material after 2016 as that timeframe coincided with when the last systematic review on game-based learning in engineering education was published [2]. We also selected to exclude work-in-progress papers since we were targeting publications where full results and analysis would be available. Our research team conducted the screening process for the returned publications using Rayyan AI [17], a software that assists with the steps of a scoping review by allowing reviewers to easily follow the iterative screening process. During the screening process there will be three screening cycles: De-Duplication, Title/Abstract Screening, and Full Text screening. For the purpose of this work in progress paper, we will present a synthesis of findings after completion of the Title/Abstract screening.

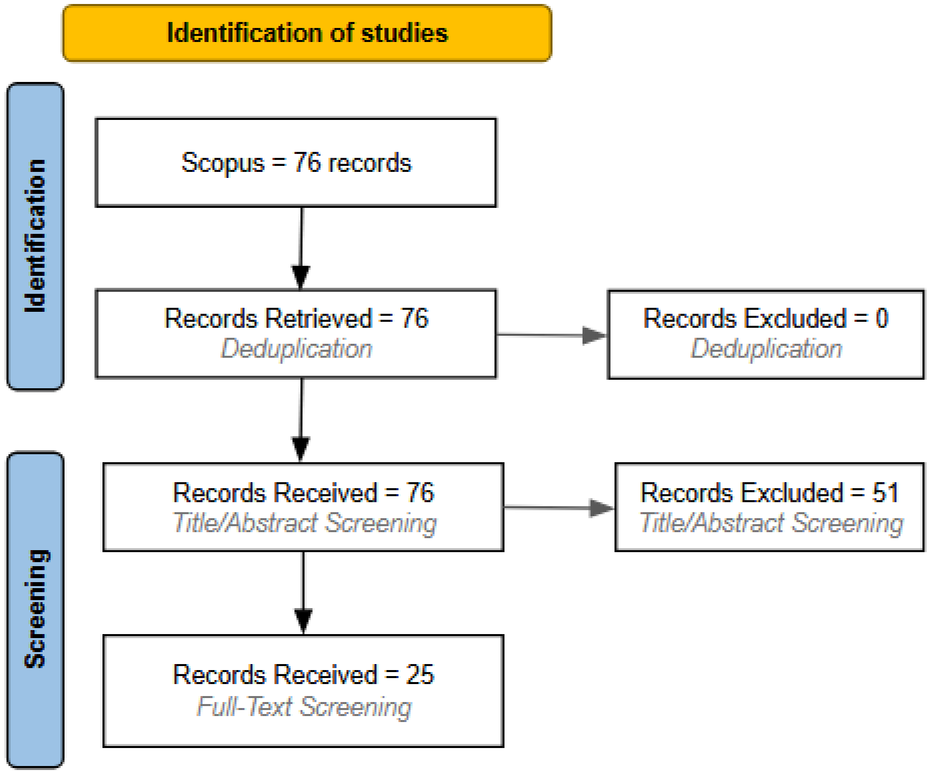

Figure 2. Pilot Study PRISMA ScR Flow Chart

The screening team consists of three researchers with defined roles on the project. The first researcher, the graduate student on this project, served as the project lead for the Scoping Review (ScR), the second researcher brought expertise in scoping reviews and has expertise in theory-driven quantitative and qualitative research methodologies, and the third researcher has experience with ScR, its protocols, and SLT which is relevant to the focus of this scoping review.

Within the title and abstract screening process the research team used the agreed upon inclusion/exclusion criteria as shown within Table 1 and Table 2 to determine which papers are relevant to the review. The initial process for each individual researcher was to categorize papers one by one as a yes, no, or maybe based on these criteria. When a paper was given a no or maybe label, the researcher provided a note within Rayyan AI to cite their reasoning, and labels for further data collection by the main investigator. After all researchers had labelled each paper during the title/abstract screening phase, the research team met to discuss any variances in decisions, as well as any papers labelled as "maybe" during screening. Through this discussion, the team came to full consensus around the inclusion criteria for each publication.

Table 1. Inclusion Criteria

Inclusion	**Definition**
Engineering Related Topic	Study is within engineering field
Education	Study is within academia or education
Digital Game-Based Learning Implementation	Method utilizes digital devices for game-based implementation

Table 2. Exclusion Criteria

Exclusion	**Definition**
Published before 2016	The paper was published prior to 2016
Review Paper/Book	The paper refers to itself as a systematic or scoping review or book
Not Engineering	The study does not focus on an engineering implementation
Not education	Study is not within the bounds of academia or education
K-12 Education	Paper focuses on K-12 population rather than academia
No use of game-based learning	Lack of any implementations of a game or game components
WIP Paper	Paper is stated as work-in-progress

Preliminary Results After Title/Abstract Screening

To date, the research team has completed the initial title/abstract screening. Initial data collection resulted in the acquisition of 76 different papers into the Rayyan-AI software for title-abstract screening. After duplicate removal and the screening process, the data pool was narrowed to 25 individual sources for full text review. Initial preliminary meta-data was reviewed to gain an understanding of publications that passed the initial title/abstract stage of the scoping review. To date, the collected data suggest that the papers focus on a variety of engineering fields with publications primarily centered on the fields of civil, mechanical, industrial, and construction engineering across both graduate and undergraduate student populations. It was also observed that some papers included engineering keywords but were not directly related to engineering programs implementing digital game-based learning strategies. One included study which does this is *"Revolutionizing education in operations management: using gamification to boost operational efficiency and supply chain management"*[18], which through the use of a simulation gamifying operations management, helped improve student decision making and encouraged students to immerse themselves in realistic scenarios. For the included papers, the research team examined whether assessment methods were mentioned in the title or abstract. Only five papers referenced the use of surveys or questionnaires as assessment tools. Additionally, fifteen papers indicated that their assessments focused on student learning outcomes, whereas only two emphasized student motivation. Because titles and abstracts do not consistently report assessment methods, theoretical frameworks, or other methodological details, further analysis of these elements will be prioritized after the full-text screening phase of the full scoping review.

Future Work

Moving forward, the team will transition from the pilot to the full scoping review by expanding the search process to capture results alongside scopus from two other databases (Eric and Engineering Village). The new publications will be collected through the use of a refined query string to provide a broader scope with less bias to then be added to the existing set of publications retrieved from the pilot; after which the research team will repeat the de-duplication and title/abstract screening process. This refined search string is: (TITLE-ABS-KEY("Gamified Learning" OR "Gamification" OR "Digital games" OR "Game-based learning" OR "Digital game-based learning" OR "Digital experiences" OR "Digital immersive environment" OR "Digital Learning Environment") AND TITLE-ABS-KEY("Engineering" OR "engineering education") PUBYEAR > 2016). Following the title/abstract screening phase, the research team will reassess the papers as part of the Full Text screening process to see if any new papers need to be eliminated based on the criteria outlined in Table 1 and Table 2. The final included papers will be fully assessed based on their relevance to the four main pillars of Situated Learning Theory, where each researcher will define important information from each publication using a coding process to determine which parts of research conducted cover Content, Context, Community, and Participation

In order to ensure rigor during the full-text screening and analysis processes the research team will conduct the process in batches of ten papers. Once each batch is complete discrepancies will be resolved through consensus meetings, forming a transparent audit trail to document screening decisions with the goal of enhancing reproducibility and reducing selection bias. The general limitations of this review are that it is restricted to published literature post-2016, which may exclude earlier studies, as well as limitations from the pilot review related to the original query selection. These limitations will be addressed in the full-scale scoping review using the refined search string. Also, as with other scoping reviews, the review’s findings will depend on the quality and completeness of reporting in the included studies, which may limit the depth of analysis.

Conclusions

Overall, this scoping review seeks to advance the understanding of assessment practices in digital game-based learning implementations within engineering education by applying Situated Learning Theory (SLT) as a guiding framework. By synthesizing existing literature through the lens of SLT’s four constructs: Content, Context, Community, and Participation; this study aims to identify gaps, commonalities, and best practices that can inform the development of standardized assessment strategies. These strategies will enable educators and researchers to evaluate digital game-based learning implementations consistently, fostering evidence-based improvements in teaching and learning.

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