Tasks-Interactions-Environment for Simulations and Serious Games (TIE-SSG) Framework: Exploring Practical Applications

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Abstract: Simulations and Serious Games (SSGs) are increasingly recognized as effective and flexible tools for supporting education. Despite their potential, selecting and appropriately using SSGs within learning pathways remains a significant challenge. To address this, the Task-Interaction-Environment for Simulations and Serious Games (TIE-SSG) framework was developed. This framework is designed to evaluate and integrate SSGs based on their fidelity levels, while adhering to instructional scaffolding principles to achieve specific learning goals (Frøland et al., 2025). This paper introduces strategies for utilizing the TIE-SSG framework to evaluate and seamlessly integrate SSGs into educational curricula, particularly for healthcare education. It outlines a step-by-step guideline that emphasizes three key phases: (1) prerequisites, (2) assessment, and (3) integration. Supporting tools and templates are provided to standardize evaluations and facilitate the alignment of SSGs with learning objectives. The practical application of the TIE-SSG framework is demonstrated through a case study on teaching phlebotomy. The case study illustrates how the framework supports the systematic integration of SSGs into educational curricula. Specifically, the approach enables the comparison, selection, and alignment of SSGs with student learning objectives, ensuring their effective use in achieving desired educational outcomes. By providing a structured approach to evaluating and integrating SSGs, the TIE-SSG framework facilitates evidence-based decision-making in educational contexts. This systematic method helps educators align SSGs with learning goals, enhancing the overall effectiveness of their use in curricula. The framework offers a robust tool for addressing the challenges of incorporating SSGs into diverse learning pathways.

Keywords: TIE-SSG, Conceptual framework, Simulations and serious games, Instructional scaffolding, Learning goals, Phlebotomy

1. Introduction

Simulations and Serious Games (SSGs) have gained recognition as effective tools for supporting teaching and learning by creating engaging, interactive, and flexible educational environments (e.g., Backlund, Engström et al. 2017, Allcoat and von Mühlenen 2018, Radianti, Majchrzak et al. 2020). They are used in many educational domains, and since healthcare education faces a number of challenges their potential is widely investigated in the field, from nursing, medical education, to pharmacology, and patient care (Graafland, Schraagen et al. 2012, Sharifzadeh, Kharrazi et al. 2020, Fens, Hope et al. 2021, Xu, Lau et al. 2021). SSGs are addressing challenges in clinical skills training, which is resource-intensive and constrained by limited access to real-world settings, time, and equipment. They promise flexible, interactive, and engaging learning experiences in safe environments, allowing students to practice critical procedures, such as blood sampling, without compromising patient safety (Froland, Elsvær et al. 2019). These tools support learning through failure, confidence building, and enhancement of fine motor skills by utilizing accessible technologies such as mobile phones, computers, and VR headsets (Vlachopoulos and Makri, 2017). However, the wide variety of SSGs and their differing levels of fidelity make it challenging for educators to select and implement the most suitable tools (Rooney, 2012). Fidelity in SSGs has long been hypothesised to have an impact on learners, dependent on their proficiency level (Alessi, 1988). Many educators are not interested in exploring technological challenges and updates, though they would like to use SSGs and other technologies to make learning goals more engaging, with increased user experiences and involvement (Dimitriadou et al., 2021). A structured framework to guide the integration of SSGs into curricula is essential to ensure alignment with learning goals, optimize their use, and address practical constraints, such as development costs and maintenance.

A previous work (Frøland et al., 2025) introduced the Task-Interaction-Environment for Simulations and Serious Games (TIE-SSG) framework, a conceptual tool designed to help educators choose and integrate SSGs into structured learning pathways. The learning pathway is the process of educational activities that support students in achieving learning goals within a curriculum. The framework is built on considering fidelity as a compound of three subdimensions: Tasks, Interactions, and Environment, aimed at evaluating the usefulness of SSGs for supporting learning activities by using instructional scaffolding principles to support progressive student development. Realistic depiction (high fidelity) often suggests easier and more intuitive usage to end-users and customers, although it can be challenging to ascertain the added value of technologies that allow higher fidelity.

The aim of this paper is to explore use of the TIE-SSG framework in practice; to assess, compare, and incorporate SSGs into teaching scenarios. By presenting step-by-step guidelines and giving illustrative examples, we aim to provide actionable insights for teachers and institutions seeking to maximize the potential of SSGs in education. The TIE-SSG framework is applied to a practical case study, identifying the main issues influencing the use of possible SSGs and integrating them into the teaching of the phlebotomy procedure, a standard procedure in many healthcare education programs. Through this example, we evaluate how the framework supports teaching practices by aligning SSG features with learning goals and facilitating collaboration through shared assessments.

The paper is organized as follows: Section 2 provides argumentations for studying the phlebotomy procedure, together with a review of relevant background literature, and includes a brief introduction to specific SSGs used as examples to demonstrate the application of the framework. In Section 3, we introduce the TIE-SSG framework, including descriptions of auxiliary tools and their usage, as well as an outline of a step-by-step guideline for assessing available or chosen SSGs. This Section also includes a proposal of methods for integrating these assessments into teaching practices. Section 4 presents a discussion of the material, and Section 5 concludes the paper.

2. Background

2.1 The phlebotomy Procedure: Aligning the Level of Fidelity to Learning Goals

To address the theory-practice gap in healthcare education and provide more suitable practice-based training (Dudley and Matheson, 2024), it is crucial to develop and evaluate strategies that better prepare graduates for professional roles. Practical learning is a crucial component in many educational programs, such as biomedical science (BMS) and other healthcare-related fields. Placing a student in a realistic environment where they must accurately perform all steps and demonstrate motor skills risks can already overwhelm them. To address issues difficult to practice in real-life contexts, it is essential to explore innovative approaches and tools that allow students to practice their procedural and technical skills. These tools are often computer-based simulation and serious games-based tools, with various degrees of fidelity (the accuracy at which reality is simulated) utilizing instructional scaffolding (Masava, Nyoni and Botma, 2022) where one can increase the complexity of the simulated environment and tasks and the level of fidelity, for increasingly advanced learning goals (Ali, Ullah and Khan, 2022; Frøland *et al.*, 2025), ensuring they are well-prepared for real-world scenarios.

SSG is one solution often used to address the barriers described for the theory-practice gap within biomedical science (Dudley and Matheson, 2024). SSGs are valuable tools for enriching the teaching and learning of topics with both low complexity (such as one clinical procedures) and high complexity (the clinical procedure in a clinical environment with several factors present). SSGs can contribute to varying the learning situations by providing engaging and interactive experiences in a wide range of forms. Virtual Reality (VR) can be used for highly immersive experiences where the student can gain a sense of being present in the virtual learning environment (Makransky *et al.*, 2020), SSGs on mobile phones are available at practically any moment, and games for PCs can be interactive and engaging (Frøland *et al.*, 2020).

While there are many potential benefits to employing SSGs into a teaching practice, it is not straightforward how and when to utilize a specific SSG for effective learning, nor how to best introduce multiple SSGs throughout a course. Likewise, when developing new SSGs, it can be challenging to identify what the gap is for the currently available ones. This paper focuses on SSGs for learning clinical procedures for phlebotomy, though many aspects of this procedure could likely be generalized to choosing and using SSGs in many other educational areas. In the current iteration, the simulation elements (depicting tasks, interactions and environmental contexts to real situations) of SSGs are in focus. Figure 1 illustrates the challenge for the teacher to help facilitate the use of SSGs in order to construct a learning pathway that keeps the student in the Zone of Proximal Development (ZPD), where the student is continually challenged according to their current level of competence.

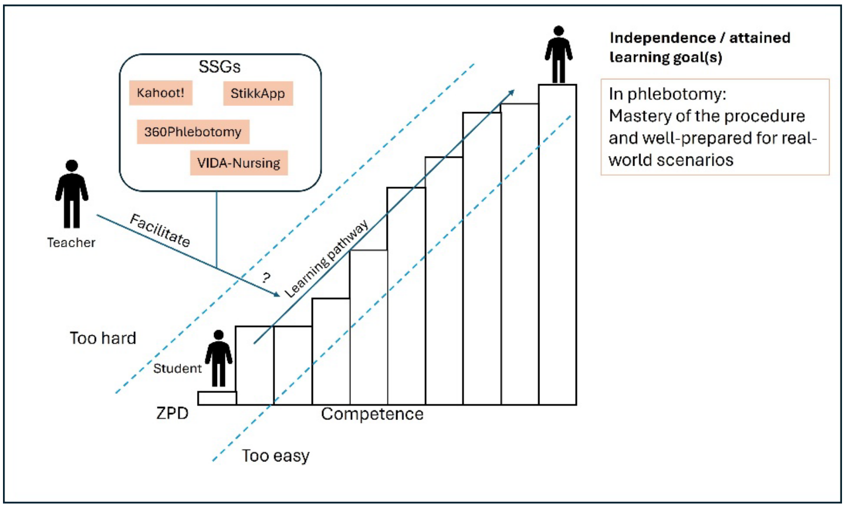

Figure 1: Illustration of the process of integrating SSGs into the student learning pathway towards phlebotomy mastery. Adapted from Frøland et al. 2025

2.2 Examples Demonstrating the Applicability of the TIE-SSG Framework

Kahoot is a widely used digital learning platform that supports active participation and interaction in classrooms, making learning more engaging and flexible. A meta-analysis of 43 experimental studies (Özdemir, 2025) shows that Kahoot has a moderate positive effect on academic achievement (effect size: 0.772) and a large positive effect on retention (effect size: 1.492) and motivation (effect size: 0.960). It also moderately reduces anxiety (effect size: −0.338) and improves attitudes toward learning (effect size: 0.678). These findings suggest that Kahoot can enhance student performance, foster engagement, and create a more supportive learning environment. Educators are encouraged to integrate Kahoot into their teaching strategies, particularly for improving retention and motivation. Regular use of Kahoot, alongside teacher training, can maximize its positive impact and support improved educational outcomes (Özdemir, 2025).

StikkApp is a Digital Game-Based Learning (DGBL) application (Frøland, Heldal, Braseth, *et al.*, 2022) designed to teach and support students in mastering the phlebotomy procedure (venous blood sampling). It provides an interactive platform for students to practice procedural steps, gain familiarity with equipment, and build confidence in performing the procedure. StikkApp also offers opportunities for repeated training and self-assessment, helping students reinforce their skills in a low-stress, simulated environment. By incorporating elements of serious games, StikkApp aims to enhance both learning outcomes and student motivation.

VIDA-Nursing v1.0 is an immersive virtual reality (VR) simulator for teaching vacuum blood collection in adult patients (Souza-Junior *et al.*, 2020). The simulator was designed to replicate 14 procedural steps. Assessments of VIDA focused on realism, interactivity, movement simulation, teaching potential, and user-friendliness (Souza-Junior *et al.*, 2020). The validation findings suggest that VIDA-Nursing v1.0 is a promising tool for enhancing phlebotomy education by integrating VR technology into the teaching of phlebotomy techniques (Souza-Junior *et al.*, 2020).

360Phlebotomy is a serious game in immersive virtual reality (VR) designed to help students become familiar with real workplaces while learning work tasks, particularly in biomedical laboratory science (BLS) education (Frøland, Heldal, Sjøholt, *et al.*, 2022). By combining virtual tasks with 360° images and videos of real laboratories, the game provides high-fidelity environments that replicate future work placements, reducing cognitive load and supporting task-focused learning. The phlebotomy process serves as the main case, with modular scene creation enabling the addition of new environments to prepare students for diverse placements. Insights from testing the prototype with five BLS teachers and six BLS students highlight the importance of realistic context in training and learning.

3. The TIE-SSG Framework

In this section, we present basic elements of the TIE-SSG framework necessary to understand its use in practical situations. The goal of the framework is to support the comparison and evaluation of SSGs for educational purposes.

The framework process is divided into three phases: Prerequisite, Assessment, and Integration. Figure 2 illustrates these phases along with their respective steps. First, *the prerequisite phase* involves steps that are performed as preparation for assessing SSGs. This means identifying learning goals through instructional scaffolding while being mindful of the fidelity dimensions for tasks, interactions, and environments, as outlined in the TIE dimensions (see Table 1). Afterwards, the teacher needs to fill out a table where they have to describe the most important aspects of each dimension that are relevant to the learning goals (see auxiliary tools, Table 2). The final step of this initial phase involves identifying potentially relevant SSGs, which can be achieved through existing knowledge, tips from other colleagues, internet searches, or other appropriate ways.

Second, *the assessment phase* begins. This is the phase where each of the identified SSGs are assessed with the identified learning goals in mind. The first step in this second phase starts with the teacher filling out a table for the SSG (see auxiliary tools, Table 2), where the relation to each dimension is described, along with a description of the envisioned activity and a description of the SSG. The next step is to compare the SSG table with the table from the prerequisite phase to determine the fidelity levels of each dimension. The TIE diagram (see auxiliary tools, Figure 3) is then filled out to visualize all the dimensions for the SSG.

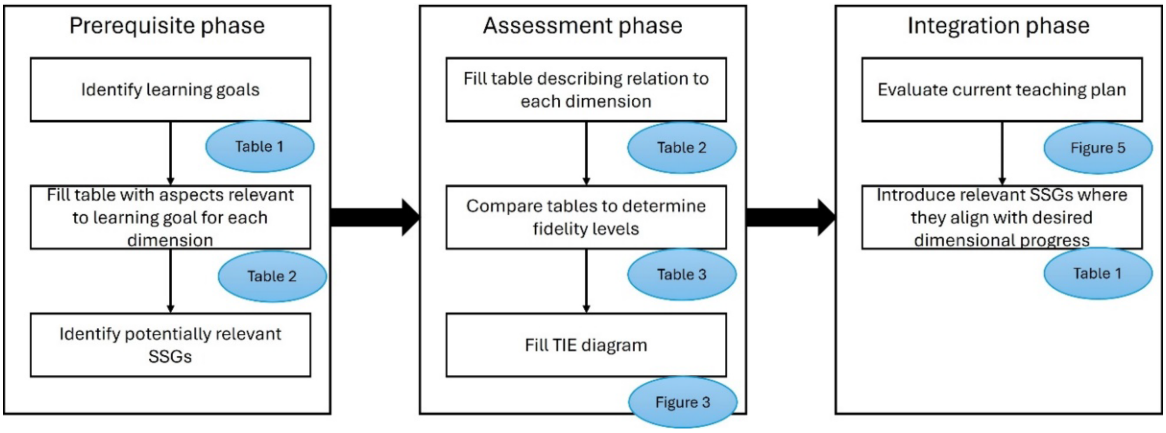

Figure 2: The three phases of the TIE-SSG framework, along with their respective steps. The figure also highlights auxiliary tools by referencing Tables 1–3 and Figures 3–5

Finally, the integration phase can begin. The first step of this final phase is to evaluate the current teaching plan, identifying the different scaffolding phases and their focus, in order to determine when it is best to introduce the specific SSGs. Finally, the SSGs are incorporated into the teaching plan to support learning goals.

Assessing SSGs to determine when to introduce them into the students' learning pathway involves several steps. A part of this decision can be supported by examining the different combinations of fidelity levels an SSG has, and how that informs us about what it could be suitable for in terms of learning. In Table 1 we provide an overview of how combinations of dimension levels can be judged in relation to their potential learning outcomes when looking at the extreme ends of the TIE dimensions. Although there are variations in these categories, they represent the major classifications that SSGs can be categorized into according to their TIE dimensions.

Table 1: Description of what can be learned from an SSG when at extreme ends.

Tasks	Interactions	Environment	Description
Low	Low	Low	Knowledge
Low	Low	High	Getting to know the environment and equipment
Low	High	Low	Motor skills
High	Low	Low	Procedural steps
Low	High	High	Contextual motor skills
High	Low	High	Contextual procedural steps
High	High	Low	Procedural steps and motor skills
High	High	High	Demonstrating knowledge, executing motor skills, and performing procedural steps in a realistic context

3.1 Auxiliary Tools for Assessment

In this section, we provide tools for assessing each SSG in relation to the TIE dimensions. The application of the tools is described stepwise in Section 3 and illustrated in Figure 2.

Table 2 serves as an auxiliary tool, allowing teachers to fill in and describe aspects of each dimension that are relevant to the learning goals.

Table 2: Fillable table for fidelity dimensions (for each SSG)

Dimension	A short description of the SSG	Fidelity
Tasks	An evaluation of the task fidelity in relation to the learning goals.	N/L/M/H
Interactions	An evaluation of the interaction fidelity in relation to the learning goals.	N/L/M/H
Environment	An evaluation of the task environment in relation to the learning goals.	N/L/M/H

*Abbreviations: None (N), Low (L), Medium (M), and High (H).

Table 3 serves as an auxiliary tool by providing a simple and structured guide to assess the fidelity of SSGs across the dimensions of Environment, Interactions, and Tasks. It provides clear criteria for distinguishing between high, medium, and low fidelity, enabling users to evaluate how closely an SSG aligns with real-world scenarios.

Table 3: Guide to fidelity levels

	Environment	Interactions	Tasks
High fidelity	The total sensory impression of the environment **closely** resembles that of the real environment.	The ways in which the user can interact with the SSG **closely** resemble those in a real case.	The tasks that the user can carry out in the SSG are **closely** tied to what would be done in a real case.
Medium fidelity	Several aspects resemble those of the real environment **quite well**.	The available interaction methods mimic real-life situations **quite well**.	Tasks that can be carried out relate **quite well** to real-world scenarios.
Low fidelity	**Few** aspects are experienced as in the real environment.	Interaction methods **somewhat** resemble real life.	Available tasks are similar to those in real scenarios to a **small** degree.

A TIE diagram (Figure 3) is then filled out to visualize all the dimensions for the SSG. The TIE diagram helps visualize the fidelity levels of the dimensions relative to the learning goal(s). The sector for each dimension is filled out according to the fidelity level. By filling only the outermost sub-sector, it is indicated that the dimension has a low fidelity level, adding the middle sub-sector indicates a medium fidelity level, and adding the innermost sub-sector indicates a high fidelity level. Filling none of the sub-sectors indicates that the dimension has none or very few similarities for that dimension.

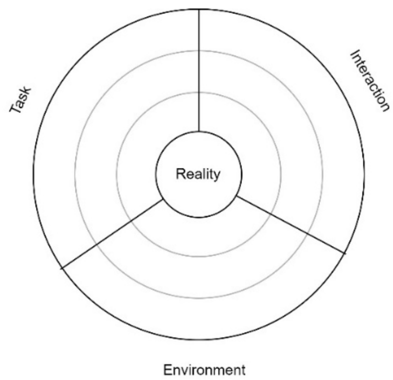

Figure 3: A model depicting the TIE dimensions

Combining all of the elements, we have a template for assessing an SSG (with an added screenshot of the SSG), as shown in Figure 4.

Name of SSG

Dimension	**A short description of the SSG**	**Fidelity**
Tasks	An evaluation of the task fidelity in relation to the learning goals.	N/L/M/H
Interactions	An evaluation of the interaction fidelity in relation to the learning goals.	N/L/M/H
Environment	An evaluation of the task environment in relation to the learning goals.	N/L/M/H

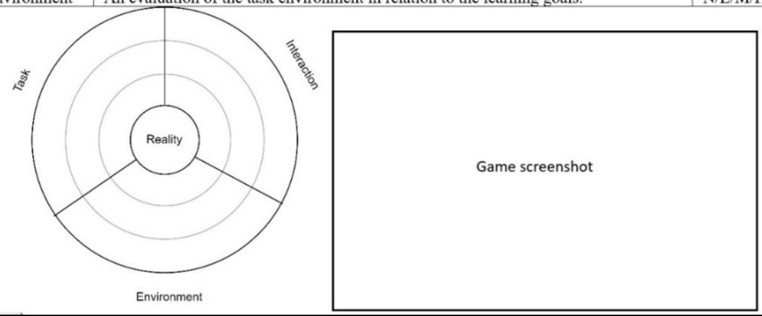

Figure 4: Template for assessing SSGs

4. Application of the TIE-SSG Framework: An Example

To illustrate how the framework can be applied, we will now provide an example of the blood sampling procedure, with each step detailed in a separate subsection.

We have chosen the phlebotomy (venous blood sampling) procedure as an example of how the TIE-SSG framework can be applied, as it is a standard procedure in many educational settings that requires hands-on training to develop the knowledge and skills necessary for practicing phlebotomy in various future contexts within their professional roles (Ialongo and Bernardini, 2016).

Phlebotomy is a key competency for various healthcare professions, but it remains a resource-intensive activity that often faces challenges in organizing sufficient training sessions. Errors in blood analysis frequently arise from pre-analytical mistakes, not only related to motoric mistakes, but also including procedural mistakes like improper handling of sample tubes, patient misidentification, and incorrect labelling of samples (Mary A *et al.*, 2023). Mastery of the procedure requires a combination of theoretical knowledge, effective communication with the patient, understanding the steps of the procedure, motor skills to physically execute it, and consideration of ethical issues.

4.1 Prerequisites

4.1.1 Instructional scaffolding and learning outcomes in phlebotomy training

Phlebotomy is a vital healthcare procedure that requires a blend of theoretical understanding, practical skills, and real-world application. Instructional scaffolding offers a structured learning process, guiding students from foundational knowledge to independent practice in clinical settings. This approach can be divided into four progressive stages for the phlebotomy (Figure 5): (i) Building theoretical knowledge, (ii) Procedural knowledge and skill application, (iii) contextual learning, and (iv) Clinical placement with authentic practice (real-world settings).

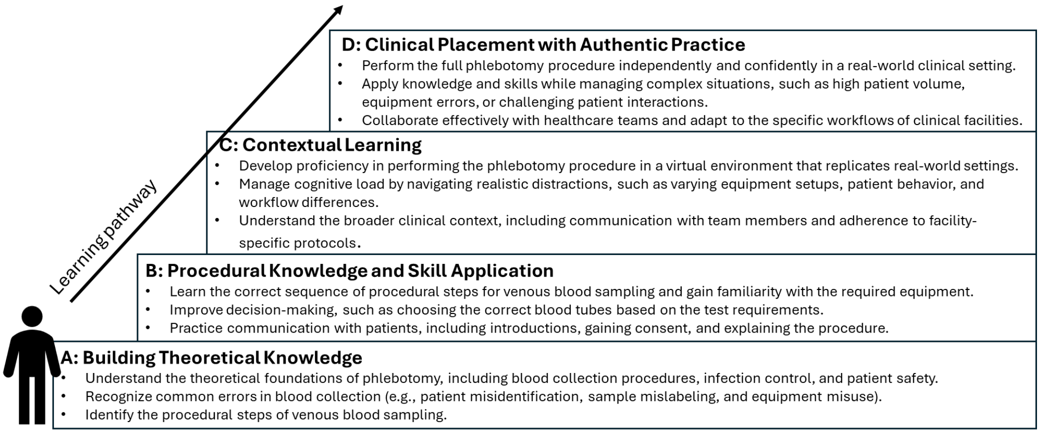

Figure 5: Learning outcome descriptions for instructional scaffolding of phlebotomy

4.1.2 Fill in the table containing the relevant aspects of each dimension

To assist in the assessment process, Table 4 (auxiliary tool, Table 2) is filled out to serve as a baseline for comparison.

Table 4: Relevant aspects of each TIE- dimension for the phlebotomy procedure

Dimension	Relevant aspects
Tasks	Carrying out a blood sampling procedure, including both knowledge and motor skill aspects. This includes communication with the patient, selecting the correct equipment, using the equipment correctly and in the correct sequence, physically inserting the cannula and drawing blood into blood tubes, labeling the samples and handling them properly, disposing of hazardous materials, and implementing safety measures.
Interactions	Relevant interactions include verbal communication and spatial interaction with the environment using hands.
Environment	A clinical setting, such as a hospital outpatient phlebotomy department or a doctor's office. All necessary equipment is available. A human patient is placed in a chair or a bed.

4.1.3 Identify potentially relevant SSGs

Through a review of relevant literature and previous experience, we have identified potentially relevant SSGs. These are described in section 2.2 and include Kahoot, StikkApp, VIDA-Nursing v1.0, 360Phlebotomy (Souza-Junior et al., 2020; Frøland, Heldal, Braseth, et al., 2022; Frøland, Heldal, Sjøholt, et al., 2022; Özdemir, 2025).

4.2 Assessment of SSGs

In the following, we evaluate SSGs where we fill out the TIE table (auxiliary tool, Table 2) and TIE diagram (auxiliary tool, Figure 3).

Kahoot

Activities	Use Kahoot quizzes to assess students' procedural knowledge, such as the sequence of blood sampling steps or safety protocols. Include collaborative and competitive sessions to engage students and enhance their retention.
Description	A quiz-based multiplayer game where players are scored based on speed and correctness. A tool for reinforcing theoretical knowledge through quizzes and interactive learning sessions.
Tasks	The player must answer questions related to the learning goals in stage A (Figure 5).
Interactions	The player clicks buttons and navigates menus with a mouse or touchscreen with no direct relation to the learning goals.
Environment	The player interacts with a 2D interface with no relevance to the learning goal.

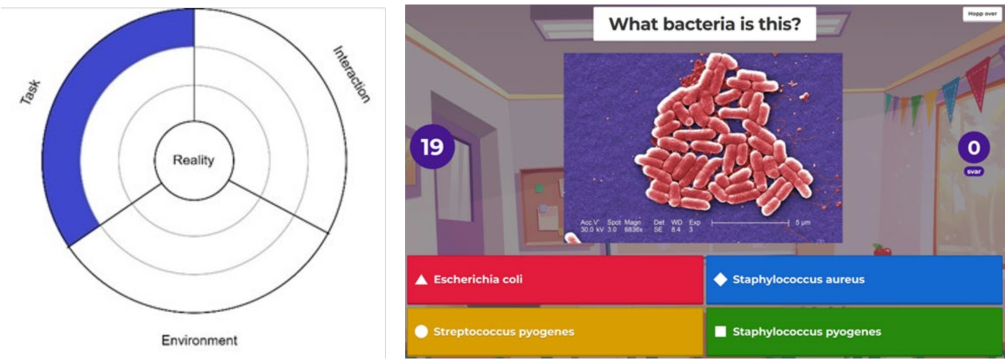

Figure 6: The TIE diagram and screenshot of Kahoot (Kahoot, 2025)

StikkApp

Activities	Use StikkApp to simulate step-by-step procedures, including vein selection, equipment handling, and patient communication. Perform self-assessment tasks in the app to evaluate procedural accuracy and identify areas for improvement.
Description	A 2D single-player game where one goes through the different parts of the blood sampling procedure. A serious game for procedural practice, focusing on task sequencing and patient interaction in a simulated environment.
Tasks	The player performs tasks, including selecting equipment, reading requisitions, and completing most, but not all, of the tasks for blood sampling, aligning well with the learning goals of Stage B (Figure 5).
Interactions	The player primarily uses a mouse or touchscreen to click on objects and navigate menus, while additional actions, such as dragging labels onto the tube and rotating the tube after sampling, add some fidelity to the interactions.
Environment	The player interacts with a 2D interface that is relevant to the learning goal, featuring images and videos of equipment and various procedure components.

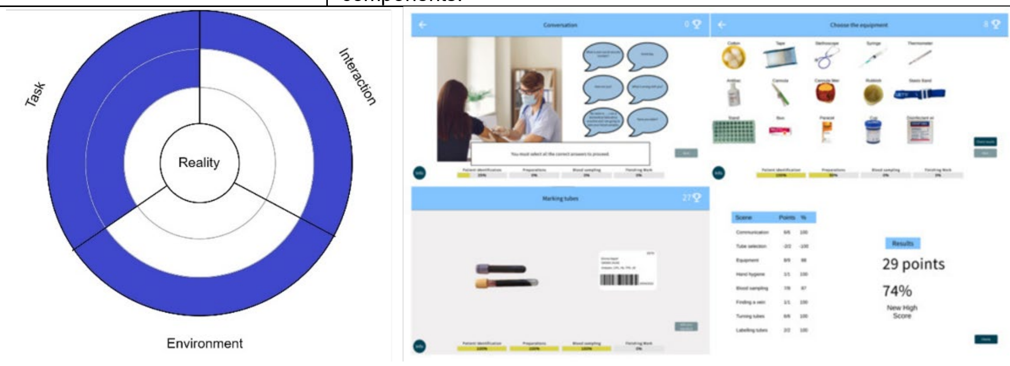

Figure 7: The TIE diagram and screenshot of StikkApp (Frøland et al., 2022)

VIDA

Activities	Navigate a VR environment and practice a phlebotomy procedure from start to finish.
Description	A 3D single-player game that guides players through the various stages of the blood sampling procedure.
Tasks	Focus on learning procedural steps and executing tasks effectively.
Interactions	The player interacts with the virtual environment through motion capture of head and hands, though haptic feedback is missing.
Environment	Limited contextual realism emphasizes core procedural skills rather than complete clinical workflows.

Figure 8: The TIE diagram for VIDA (Souza-Junior et al., 2020)

360Phlebotomy

Activities	Navigate 360°-VR environments in clinical settings, practicing the full phlebotomy procedure from start to finish. Work through realistic workflows, including patient communication, navigation of work environments, and proper labeling.
Description	A VR singleplayer game based on 360°-video where the student can explore a virtual laboratory, take part in a virtual blood sampling session and carry out a blood sampling round at the local hospital.
Tasks	Many relevant tasks are included, such as navigation in a clinical environment, information gathering, and performing procedural steps.
Interactions	The player interacts with the environment through motion tracking of the head and hand controllers. Actions are taken by pointing and clicking with the hand controller.
Environment	Provides a visually immersive experience with 360° visuals of real environments and contextual workflows. Illustrates differences between university teaching laboratories and hospital environments.

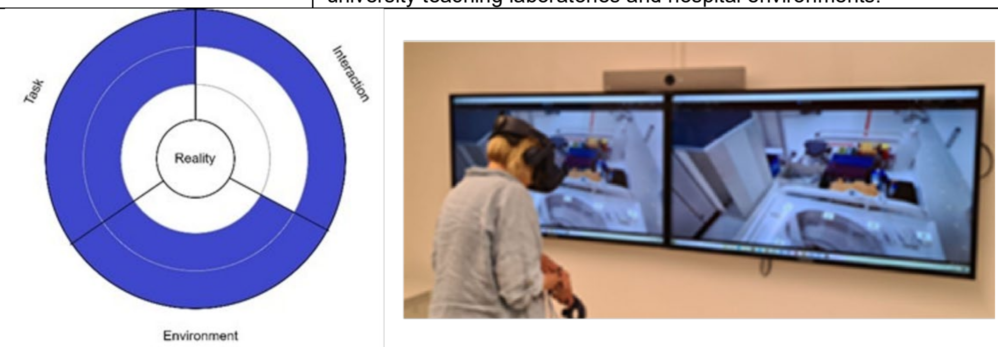

Figure 9: The TIE diagram for 360Phlebotomy (Frøland et al., 2022)

Clinical Placement with Authentic Practice

Activities	Independent practice in real-world clinical settings under supervision. Students perform the complete phlebotomy procedure while managing complex scenarios, including high patient volumes, equipment malfunctions, or challenging patient interactions. They collaborate effectively with healthcare teams and adapt to the specific workflows and protocols of clinical facilities.
Description	A physical simulation setting where the students will perform the blood sampling procedure on patients under supervision.
Tasks	The tasks to be performed are the same as in a real case, according to the learning goals.
Interactions	The interactions are highly realistic.
Environment	The environment is almost indistinguishable from that of a real blood sampling situation, except for the presence of a supervisor.

Figure 10: The TIE diagram and image of physical simulation in clinical settings (Delaware, 2005)

4.3 Integration

The TIE-SSG framework provides a structured approach to integrating SSGs into educational pathways by aligning fidelity dimensions with learning goals. By assessing the task, interaction, and environmental fidelity of each SSG, educators can strategically position these tools within a progressive learning path. Low-fidelity tools, such as knowledge-based quizzes, can support foundational learning, while moderate-fidelity tools focus on procedural knowledge, and high-fidelity simulations emphasize contextual learning and real-world application.

The framework facilitates instructional scaffolding by ensuring each SSG contributes meaningfully to the student's progression, from theoretical understanding to independent practice. Visual models and supporting tables within the framework enable educators to effectively evaluate and sequence SSGs, creating a learning pathway that balances complexity and student engagement. By using the TIE-SSG framework, educators can optimize the integration of SSGs to support student development and achieve targeted learning outcomes. Based on the assessments of the selected SSGs, a suggestion for stages where the SSGs would be valuable to introduce is presented in Figure 11.

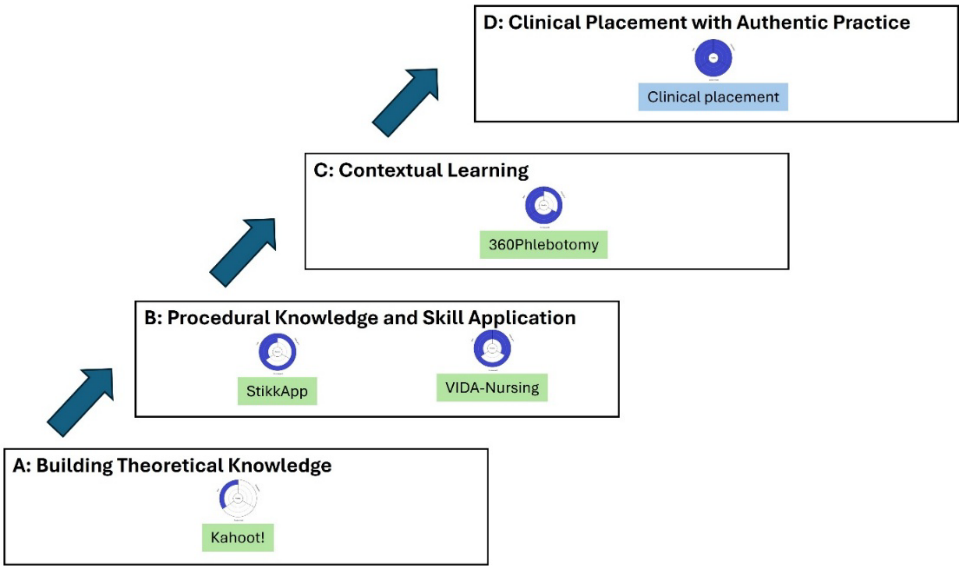

Figure 11: Placement of SSGs through the learning stages

5. Discussion

The TIE-SSG framework offers a structured approach for assessing the fidelity dimensions of SSGs across various stages of instructional scaffolding. When applied to tools like Kahoot, StikkApp, VIDA-Nursing, and 360Phlebotomy, the framework highlights their strengths and limitations in task, interaction, and environmental fidelity. For low-fidelity tools like Kahoot, the framework effectively positions them within foundational learning stages, where the development of theoretical knowledge needs to be emphasized. Moderate-fidelity tools like StikkApp and VIDA are well-suited for learning procedural skill development, where the benefits of the framework was for identifying and highlighting areas for improvement, such as enhancing contextual realism or interactivity when these are needed. High-fidelity tools like 360Phlebotomy excel in contextual learning, offering immersive environments that prepare students for real-world clinical settings. By utilizing the TIE-SSG framework we were able to differentiate and motivate suitable SSGs for alignment with various requirements of training and learning phlebotomy.

Currently, the TIE-SSG framework is primarily focused on clinical skills and procedures. While it may have utility in other fields, adaptations may be required to ensure it fits different educational contexts. Additionally, SSGs are complex tools, and the current assessment method inevitably simplifies some aspects of their evaluation. This version of the TIE-SSG framework aims to strike a balance between including sufficient information for comparison without becoming overly detailed, while focusing predominantly on the simulated aspects of SSGs. However, certain elements, such as adaptivity, feedback, game mechanics, ethics, and communication, may warrant further consideration in future iterations. For example, game-like features may be more effective at early learning stages to enhance motivation, while higher fidelity resembling real-world scenarios becomes more crucial at advanced stages.

Despite its current limitations, the TIE-SSG framework offers valuable insights into aligning SSGs with learning goals and scaffolding stages, supporting educators in integrating these tools into progressive learning pathways. Future iterations of the framework could integrate additional dimensions, such as the role of game mechanics and learner motivation, to provide a more holistic evaluation of SSGs across diverse educational contexts.

6. Conclusions

This paper presents the TIE-SSG conceptual framework and demonstrates its application in an educational context, using the blood sampling procedure as an example. A step-by-step guide, along with tools for visualizing fidelity levels and analysing SSGs, was provided to support its implementation.

Future research should focus on testing the framework in further practical settings to evaluate its effectiveness and ensure its applicability. Expanding the framework to incorporate game mechanics and genres could enhance its utility. By refining and applying the TIE-SSG framework, teachers can more effectively integrate SSGs into their teaching practices and align them with educational goals.

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Ethics declaration: No ethical clearance was required for the research.

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