The Perceived Gameful Experience of Undergraduate Nursing Students Engaged in a Virtual Interactive Puzzle Escape Room Focusing on a Complex Clinical Intervention

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Contributions

I, *Sylas Coletto*, am the primary investigator and author of this Master of Science in Nursing thesis research study. I contributed to creating, developing, and producing the virtual simulation depicted in the thesis work. I contributed to identifying, developing, and writing the research question, study purpose, the study's importance, literature review, philosophical underpinning, conceptual framework, methodology, data analysis, data findings, and implications to nursing practice, research, and education.

Dr. Jane Tyerman is the thesis supervisor for this thesis research study. Dr. Tyerman contributed to creating, developing, and producing the virtual simulation depicted in the thesis work. Dr. Tyerman played an integral role in the thesis development, including developing the research question, providing feedback on written thesis work, and providing guidance when selecting an appropriate research paradigm, design, and methods. Furthermore, Dr. Tyerman is an editor of the thesis work.

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Victoria Cole is the Health Sciences Librarian at the University of Ottawa. Victoria contributed to the search strategy and helped find essential literature for this research.

Abstract

Background: With the increased emphasis on technology-based education, in-person educational escape room puzzles are gaining popularity in higher education. In response to challenges in delivering quality education within the virtual environment, the need to expand learning opportunities within the digital environment has never been greater. **Methods**: The purpose of this study is to investigate nursing students' experience using gamification Virtual Interactive Puzzle Escape Room (VIPER), which incorporates tasks of medication calculations and safe blood transfusion procedures. Using a quasi-experimental explanatory post-test design, the sample consisted of (N=52) third-year nursing students enrolled in a medical-surgical nursing course from Ottawa, Ontario. The reliable and validated GAMEX tool was used to assess the gameful experience of the VIPER. A secondary question identified if age of participants influence their gameful experience scores. **Results**: Participants perceived VIPER improved knowledge, skills and judgement and can be an effective educational modality to apply skills of medication calculations and reinforce the nursing skills in complex clinical interventions. **Conclusions**: By incorporating creative and engaging game elements into nursing education, educators can enhance the learning experience of nursing students and prepare them to provide high-quality patient care.

Keywords: *medication calculations, escape rooms, gamification, nursing education*

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Chapter 1: Introduction

Background

Nursing education is crucial in preparing nurses to provide safe, effective, and patient-centred care in the clinical environment. In order for nursing education to be relevant to the current clinical environment, it must reflect the changing healthcare landscape and the evolving needs of patients (Pront & McNeill, 2019). Nurse educators facilitate innovative ways to educate nursing students that support knowledge application and retention, ensuring they are prepared to provide safe and quality care in a highly complex healthcare system. Certain skills within nursing, such as medication calculation, critical thinking and judgement, are both universal and essential and are utilized within complex clinical interventions for patient well-being. Complex clinical interventions play an important role in nursing. Developing teaching modalities that allow nursing students to effectively practice these skills within the healthcare environment may support positive patient outcomes.

Simulation

Defined by Thornton, Mueller-Hanson and Rupp (2017), simulation-based learning is "an activity resembling an organizational situation in which participants are presented with complex stimuli and required to display complex overt behaviour" (p. 4.). In medical education, simulation is a tool used to recreate environments where medical procedures and tasks are performed so clinicians can learn, practice, and improve their technical skills and nontechnical skills, including communication and teamwork (McGovern, 1994; Vortman, 2020). Utilized within healthcare education (e.g. nursing, medicine, pharmacy, physiotherapy), simulation facilitates learning in a realistic environment where the consequences of making mistakes will not cause harm to a patient (Dillon et al., 2021). During simulation, students can make mistakes

such as inappropriate medication administration and other unsafe nursing care but are able to learn from these experiences without harming anyone (Yuan et al., 2012).

The benefits of simulation-based learning have been the focus of nursing education research (Gopalan et al., 2017; Kaše et al., 2019; Miller & Bull, 2013; Tohidi & Jabbari, 2012). Using simulation in nursing education has become integral, directly challenging students' critical thinking, clinical judgement, and safe clinical practice (Owegi et al., 2021). In their systematic review, Yuan et al. (2012) found that simulation effectively enhanced knowledge and performance on skill exams; however, simulation is not without challenges, including logistical and fiscal requirements. Employing institutional faculty to run the operation, facilities available for simulation, equipment costs, and logistics to connect students to the facilities are some challenges when implementing in-person simulation experiences (Miller & Bull, 2013). Additionally, the 2020 global pandemic resulted in significant restraints on in-person gatherings and guidelines for social distancing between individuals in group settings. Should they be reimplemented, using simulation can help maintain public health guidelines.

Implementing a variety of education modalities, such as simulations, require applying nursing theories to practice that are comprehensive, safe and effective and follow professional standards (Pront & McNeill, 2019). Tailoring the educational approach to support nursing students' confidence in executing medication calculations can positively affect patient safety (Williams & Davis, 2016). The more students feel confident in their ability to perform a task successfully, the higher their achievement (Khalaila, 2015). A significant responsibility falls on nursing educators to build a system that fosters student development, including self-confidence and positive academic self-concepts (Khalaila, 2015; Owegi et al., 2021; Quinn & Peters, 2017).

Designing an educational environment replicating a clinical setting and providing a psychologically safe learning experience where students apply knowledge and learn from mistakes without causing patient harm should be prioritized (Turner & Harder, 2018). Simulation-based experiences and virtual simulation have been implemented to meet this need more recently. A novel approach requires strategies to facilitate knowledge retention and resource accommodation while decreasing anxiety, improving learning motivation, and maximizing on-demand access.

Gamification

Gamification is the use of game elements or principles in a nongame (Brull & Finlayson, 2016; Johnson et al., 2014). Serious games, a form of gamification, are educational game-based experiences aimed toward problem-solving rather than entertainment (Lioce, 2020, p. 42; Pilote & Chiniara, 2019). Utilized in nursing education, serious games address the current learner (e.g. Millenial and GenX), engaging learners in a low-stress, psychologically safe environment (Connelly et al., 2018). Educators can design a game to target a specific area of learning that may not be accessible to all learners within the clinical learning environment. Multiple forms of serious gaming are utilized in nursing education, such as in-person escape rooms, and digital-based games (Paim & Goldmeier, 2017; Thangavelu et al., 2022).

Escape Rooms

The creation of serious games for education is limited by the creator's imagination. In-person escape rooms are becoming increasingly popular as a form of gamification (Backhouse & Malik, 2019; Garwood, 2020; Gómez-Urquiza et al., 2019; Vestal et al., 2021). Escape rooms require the learner or group of learners to solve simple to complex puzzles within an escape room environment. Requiring problem-solving and critical thinking skills, the learner(s) solves

individual puzzles to uncover clues to progress the learner to the next stage of the escape room until solved and the participants have completed the required task (Garwood, 2020). Escape rooms offer an excellent way to ensure a learner has correctly identified the proper procedure before they can move on to the next step. This applied learning method aligns well with safe medication calculation and administration. The puzzle escape room will not allow the learner to move from the first step to the second until the learner correctly determines the medication, the dosage, and then rate of infusion.

Virtual Simulation

Virtual simulation is defined as interactive education-based games where the learner progresses through screen-based simulations that realistically portray clinical experiences (Cant et al., 2019). The learner engages in clinical decision-making to control the interaction within the virtual environment (Lioce, 2020). The virtual environment can replicate clinical experiences, exposing learners to common clinical situations within a controlled environment (Tyerman et al., 2019).

Shifting education from an in-person to an online environment has forced many educators to embrace innovations in teaching and learning, encouraging the uptake of new digital-based learning strategies. Virtual simulation offers an alternative when nursing clinical practicums are limited or unavailable (Kubin et al., 2021). Offering a high level of environmental fidelity, the degree to which the simulated environment replicates reality, virtual simulations immerse the learner into a realistic clinical setting in a digital platform. This offers essential learning opportunities, especially in situations when on-site clinical placements are restricted.

Virtual simulation has recently been used to simulate complex clinical interventions that may not be easily accessible in traditional clinical settings. Virtual simulation facilitates

repeatability, where participants can make mistakes and review their performance. For example, simulations of high-risk procedures or emergencies can be created to expose nursing students to these situations in a controlled environment. If errors occur, there is no risk to a patient, and the student can receive feedback from their instructor. Sachedina et al., 2019 interviewed (n=33) resident physicians in internal medicine, family medicine, anesthesia, cardiac surgery, and emergency medicine on their Cardiac Care Unit rotation from a London, Ontario Hospital after participating in a code blue simulation program. Using thematic analysis, the authors concluded that the code blue simulation program enhanced resident preparedness to participate in code blues.

Complex Clinical Interventions

Complex clinical interventions, as defined by Craig et al. (2008) are "…interventions that contain several interacting components…" (p. 979). This is expanded on by Campbell et al. (2007), who highlight the importance of understanding that complex clinical skills are often layered with individual skills and how they are implemented within the larger context of healthcare systems. Therefore, complex clinical interventions in nursing refer to a range of procedures, treatments, or interventions that require advanced knowledge, skills, and decision-making abilities on the part of the nurse. These interventions are often used to treat patients with complex conditions, and they may involve multiple components, such as medications, devices, and therapies. Examples of complex clinical interventions in nursing include blood transfusions, chemotherapy, mechanical ventilation, and wound care.

Complex clinical interventions require the nurse to use a systematic and evidence-based approach to assess, plan, implement, and evaluate the care provided to the patient. This approach involves a range of competencies, including critical thinking, clinical reasoning, and

communication skills, to ensure the safety and effectiveness of the intervention. These interventions are a coalescence of knowledge and skills that are developed over years of education and require practice to become proficient (Campbell et al., 2007).

Blood transfusion – as a complex clinical intervention

Nurses play a critical role in the safe administration of blood transfusions. Blood transfusion, a complex clinical intervention, involves the infusion of blood or blood components into an individual as a life-saving treatment. Blood transfusions are a common medical intervention used to replace blood loss, improve oxygen delivery, and correct blood-related disorders. Blood transfusions can be considered a liquid transplant, where one person is given a component of their body to help save another person's life (DeLisle, 2018). Millions of people require life-saving blood transfusions throughout the world, and nurses play an integral role in performing these transfusions (Hijji et al., 2013). Canadian Blood Services (CBS) annually collects approximately 1 million blood or blood component units. This procedure, however, is not without risks as potential complications can be life-threatening, where administrative and nursing staff are heavily relied upon to ensure the safety of the patients (Canadian Blood Services, 2019).

Blood transfusions, as a complex clinical intervention, require extensive knowledge and skills on the part of the nurse, including medication, pre/post-transfusion assessments, blood product and equipment compatibility, and intravenous flow rate calculations. Several factors, such as patient history, blood type, and transfusion reactions, must be considered to ensure the safety and efficacy of the procedure. Nurses must recognize and respond to adverse reactions promptly and provide appropriate supportive care to minimize the risk of complications (O'Reilly, 2020).

During a transfusion, the nurse must closely monitor the patient for any signs of adverse reactions, such as fever, chills, shortness of breath, or urticaria. The nurse must also ensure that the transfusion is administered correctly, at the appropriate rate, and that the patient's vital signs are monitored continuously. In the event of an adverse reaction, the nurse must be prepared to stop the transfusion immediately and provide appropriate interventions, including medications or supportive care (Laureano et al., 2020).

Medical Errors

Many practitioners are involved in the medication process, including; nurses, physicians, pharmacists, and pharmacy technicians. Errors can occur at any stage of the medication process. Nurses have a significant role in medication transcription, preparation, dispensation and administration. Within intensive care units (ICU), medication errors are often related to drug dosing, calculation, and administration of intravenous (IV) medications (Hussain & Kao, 2005). The complexity of medication calculation increases when the nurse has to determine medication dosage based on patient weight and rates of IV administration (Hussain & Kao, 2005). It is a practice standard that nurses learn how to calculate and administer medications safely. This starts while nurses are students enrolled in nursing school.

Negative patient outcomes of medical errors can result in cognitive impairment (e.g. confusion, agitation), physical issues (e.g. falls, pressure wounds) and increased rates of morbidity and mortality (CIHI, 2021a; Feleke et al., 2015). In Canada, medical errors are common and can lead to disastrous outcomes (Gagnon, 2004). Medical errors often surround the medication process, where the World Health Organization indicates the medication process comprises five general stages: prescribing, dispensing, administering, monitoring and use (World

Health Organization, 2017a). During 2020-2021, 1 in 17 hospital stays involved at least one harmful event; 46% were related to medication errors (CIHI, 2021a).

CIHI reports that from 2014 to 2020 in Canada, medication-associated errors have increased by 12.7% (CIHI, 2021b). One in nine adults report that a health professional or hospital gave them the wrong medication or dosage, resulting in an additional 1.1 million extra days in the hospital (Gagnon, 2004). Decreasing the number of medication-related errors is paramount to patient safety and well-being, and the effective function of the health care system. A medication error is defined by the College of Nurses of Ontario (CNO) as: "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer" (CNO, 2019, p. 7).

Medication Calculations

Blood products are delivered directly into the patient's bloodstream through an intravenous (IV) catheter, typically inserted into a vein in the patient's arm. One critical aspect of IV therapy and transfusions is the flow rate calculation, which refers to the rate at which the medication or fluid is administered to the patient. Flow rate calculations are essential to ensure that the patient receives the correct dosage and that the medication or fluid is delivered safely and effectively. Failure to accurately calculate flow rates when administering blood and blood products can lead to transfusion reactions. The most common adverse reactions in Canada include transfusion-associated circulatory overload, febrile non-hemolytic reactions, minor allergic reactions, acute hemolytic reactions, and delayed hemolytic reactions (Public Health Agency of Canada, 2021). Human error accounts for a significant portion of mistakes for blood transfusions. Most of these human errors occur before blood transfusions are complete, including

incorrect blood tubing, incorrect rates when administering blood, and failure to correctly identify a patient (Bolton-Maggs, 2016; Flood & Higbie, 2016; Hijji et al., 2013). Adverse events occurring from a transfusion reaction resulting from human error can have catastrophic results for the patient (DeLisle, 2018).

To calculate the flow rate for an intravenous blood transfusion, the nurse must consider several factors, including the amount of blood to be transfused and the duration of the transfusion. The flow rate is typically expressed in millilitres per hour (ml/hr) or drops per minute (gtts/min), depending on the type of intravenous tubing used and whether the infusion is going through a pump (Lord, 2023).

The nurse must continuously monitor the flow rate during the transfusion to ensure it remains within the prescribed range. The nurse should also monitor the patient for any signs of adverse reactions, such as fever, chills, or allergic reactions, and report any adverse events immediately. Intravenous blood transfusions require careful calculation and monitoring of the flow rate to ensure that the patient receives the correct dosage and that the medication or fluid is administered safely and effectively (Lord, 2023). Understanding the principles of flow rate calculations and closely monitoring the patient during the transfusion is essential for the safe administration of blood and blood products.

Mitigating blood transfusion reactions requires proper information gathering, such as patient identifiers, calculating administration rates over specific timeframes, and prompt knowledge and recognition of an impending reaction. Preventing worsening reactions and severity requires administering blood products at an appropriate rate, where preventing any additional drop of blood into the patient can help prevent worsening reactions (Public Health Agency of Canada, 2002; Public Health Agency of Canada, 2021). Determining the appropriate

rate at which blood is administered requires medication calculations. The importance of these calculations can have life-or-death implications for the patient (Conti & Beare, 1988).

Therefore, nurses must have the required knowledge and skills related to the safe administration of blood products, including flow rate calculations, management of adverse reactions and subsequent drug dose calculations to manage adverse reactions (Malhotra et al., 2022).

Medication and Flow Rate Calculation in Nursing Curriculum

Nursing education routinely uses a curriculum design that builds upon information previously learned; students in the second year of their program rely on information learned during the first year (Pront & McNeill, 2019). In undergraduate nursing education, nursing students learn to apply medication administration knowledge systematically and reliably (Williams & Davis, 2016). Additionally, newly hired nurses in clinical areas need carefully planned orientation and supervision of medication administration (Malhotra et al., 2022), with particular attention paid to medication dosing calculation.

The nurses' medication calculation proficiency is central to medication safety (Armitage & Knapman, 2003). As an essential skill, the CNO developed the Practice Standard for Medication, emphasizing the nurse's accountability when dispensing and administering medications (CNO, 2019). Accurate medication calculations can range from simple to complex depending on factors such as the patient's age, health status, comorbidities, and weight. However, nursing students' medication calculation skills are poor (Caboral-Stevens et al., 2020; Goodwin et al., 2019). As well as having significant consequences for the patient, medication errors are considered to be major adverse events; thus, they are costly for healthcare systems (Stolic et al., 2022; World Health Organization, 2017b). Medication calculations are challenging

for nursing students resulting in increased stress and anxiety (Conti & Beare, 1988; Owegi et al., 2021).

Nursing students struggle with medication calculations, and these calculations are common in nursing practice (Conti & Beare, 1988; Owegi et al., 2021). Determining the correct medication dose and/or intravenous flow rate is paramount to the safety of that patient (Williams & Davis, 2016). The accuracy of drug dosage calculations and intravenous flow rates rely on accurate mathematical calculations. As noted above, in the case of blood transfusions, the rate at which medications are administered can also have profound implications for patient outcomes. In a cross-sectional study in the United Kingdom, 92% of students and 89% of graduate nurses failed the administered drug calculation test (McMullan et al., 2010). Medication calculations are often a component of a complex clinical intervention and thus need to be completed accurately. Failure to complete the medication calculation properly could result in the entire complex intervention failing, putting the patient's well-being at risk.

Significant anxiety surrounds clinical education, mathematical calculations, and pressure to learn and perform life-saving procedures (Khalaila, 2015). Compounding nursing student anxiety surrounding medication calculations is the understanding that these students will be responsible for performing life-saving procedures upon graduation. Paradoxically, the current education format of high-stakes testing is strongly linked to triggering testing anxiety, which decreases performance and undermines student performance (Owegi et al., 2021; Quinn & Peters, 2017).

Initiating medication calculation training beginning in the early stages of the nursing program supports basic math skill development. Undergraduate nursing students are required to complete clinical practicums throughout their nursing program. In clinical practicums, students

routinely administer medications to patients (Musharyanti et al., 2019). As students progress through the nursing curriculum, they are exposed to increasingly complicated medication calculation requirements, and students are often required to have high marks to pass. Students who lack proficiency in basic math skills face significant challenges in performing complex calculations.

Education Gap

Nurse educators need to ensure that graduates of nursing programs have established knowledge and skills in medication and flow rate calculations that are especially relevant to the safe administration of blood and blood products (Tan et al., 2017). Thus, adequate and repeated training/education opportunities need to be provided throughout nursing programs providing ongoing opportunities for nursing students to develop skills and enhance knowledge in safe medication administration practices.

Educational interventions provide an opportunity to bridge knowledge utilization and application of complex clinical skills, such as blood transfusions (Malhotra et al., 2022). Creating learning opportunities that integrate complex clinical interventions are needed to allow students to practice these skills within a safe and controlled environment without risking patient safety. Designing educational tools that combine clinical skills empowers learners to think critically and problem-solve (Mousavinasab et al., 2020). Integrating computers and other technologies into nursing education could address this educational need and facilitate student learning to safely and effectively implement complex clinical interventions (Mousavinasab et al., 2020).

High levels of medication errors are occurring and continuing to increase, improving the modalities that nursing students learn and become competent in working with medications needs

to occur. This is also the case for facilitating ideal education practices for complex clinical interventions, which include blood transfusions.

Blood Transfusions

Blood transfusions are the exchange of blood from one individual to another and are considered a life-saving procedure that, if done incorrectly, can have disastrous outcomes for patients (Canadian Blood Services, 2019; DeLisle, 2018). Similar to medication errors, blood transfusions rely heavily on skilled practitioners to execute correct procedural practices to ensure patient safety and minimize the risk of negative patient outcomes (Hijji et al., 2013). Negative patient outcomes can result in hemolytic reactions, which lead to disability or death (DeLisle, 2018).

Education regarding Blood Transfusions

Upon graduation and integration into the working environment, graduate nurses navigate a complex healthcare system where errors commonly occur (Treiber & Jones, 2018). Graduate nurses must be adequately prepared to practice, especially when completing complex and potentially fatal procedures such as blood transfusions. Encan and Akin (2018) conducted a descriptive cross-sectional study examining the knowledge levels of Turkish nurses regarding blood transfusion practices. A total of 171 nurses completed a knowledge questionnaire with 40 questions regarding blood transfusions. The results indicated that nurses have a moderate level of understanding regarding blood transfusion. The authors emphasize the importance of improving nurses' knowledge of blood transfusions, which can aid in ensuring patient safety surrounding blood transfusion and monitoring for adverse reactions (Encan & Akin, 2019).

These results are further supported by Mukhlif and Khalil (2017), who conducted a descriptive study of (n=130) graduate nurses in Mosul City. The researchers administered a

questionnaire with 16 questions about blood transfusions. Results identified 35% of nurses reported poor knowledge regarding blood transfusion procedures. The authors recommend in-service education programs emphasizing blood transfusion knowledge and skills for graduate nurses (Mukhlif & Saad Khalil, 2017). Of note, the graduate nurses in this study completed the required education before becoming professional nurses, including nursing school, nursing diploma, and vocational preparatory nursing school.

Mitigating negative patient outcomes requires proper and effective education at both the professional level and upstream within the nursing student educational curricula. As indicated above, traditional forms of didactic lecturing may not also result in adequate knowledge acquisition about blood transfusions (Yuan et al., 2012). This is supported by Shamshirian et al. (2017) in their descriptive cross-sectional study on the knowledge and awareness of n=153 undergraduate nursing students in Iran. The researchers administered a questionnaire that included specific questions about blood transfusions to the nursing students, where the results indicated only 25.9% of students reported a perceived 'good' understanding of blood transfusions procedures. The researchers did not identify the education level of the students enrolled in the study. The results indicated a knowledge gap exists among nursing students, many of whom struggle with awareness and knowledge specific to blood and blood product administration (Shamshirian et al., 2017).

Research Problem

There is a need to provide nursing students with opportunities to apply skills involving math calculations and critical interventions to ensure safe patient care. The purpose of this study is to investigate nursing students' experience using gamification Virtual Interactive Puzzle Escape Room (VIPER), which incorporates various medication calculations and safe blood

transfusion procedures. Since VIPERS are a novel innovation with minimal research conducted to date, the research problem is being investigated through a mixed-methods research design.

Research Question:

What is the perceived gameful experience of undergraduate nursing students engaged in a virtual interactive puzzle escape room (VIPER) focusing on a complex clinical intervention? A secondary question will identify if age of participants influence their gameful experience scores.

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Chapter 2: Literature Review

A literature review was conducted to explore how complex clinical interventions and related clinical skills of medication calculations are taught within undergraduate nursing education. This literature review helped identify the current practices within the field of nursing education and associated challenges. The literature guided the researcher through designing the appropriate research strategy to answer the research question.

Search Strategy

A comprehensive literature search exploring complex clinical interventions and related clinical skills of medication calculations in nursing education using virtual simulation was completed using the CINAHL, PsycINFO (Ovid), Pubmed, Medline, Scopus, Embase, and Education Source electronic databases. These databases were accessed through the University of Ottawa's Health Sciences Library and captured various interdisciplinary research. The University of Ottawa Health Science Librarian also provided initial guidance when navigating the databases. Following database searches, manual reference lists, grey literature, and Google Scholar searches were completed to retrieve relevant literature. The phenomenon of interest, design, evaluation, and research (SPIDER) tool for qualitative synthesis as a framework was used to guide the literature search (Cooke et al., 2012). Search terms and database-specific Medical Subject Headings (MeSH) were used. All MeSH headings were searched using the "explode" feature to maximize results.

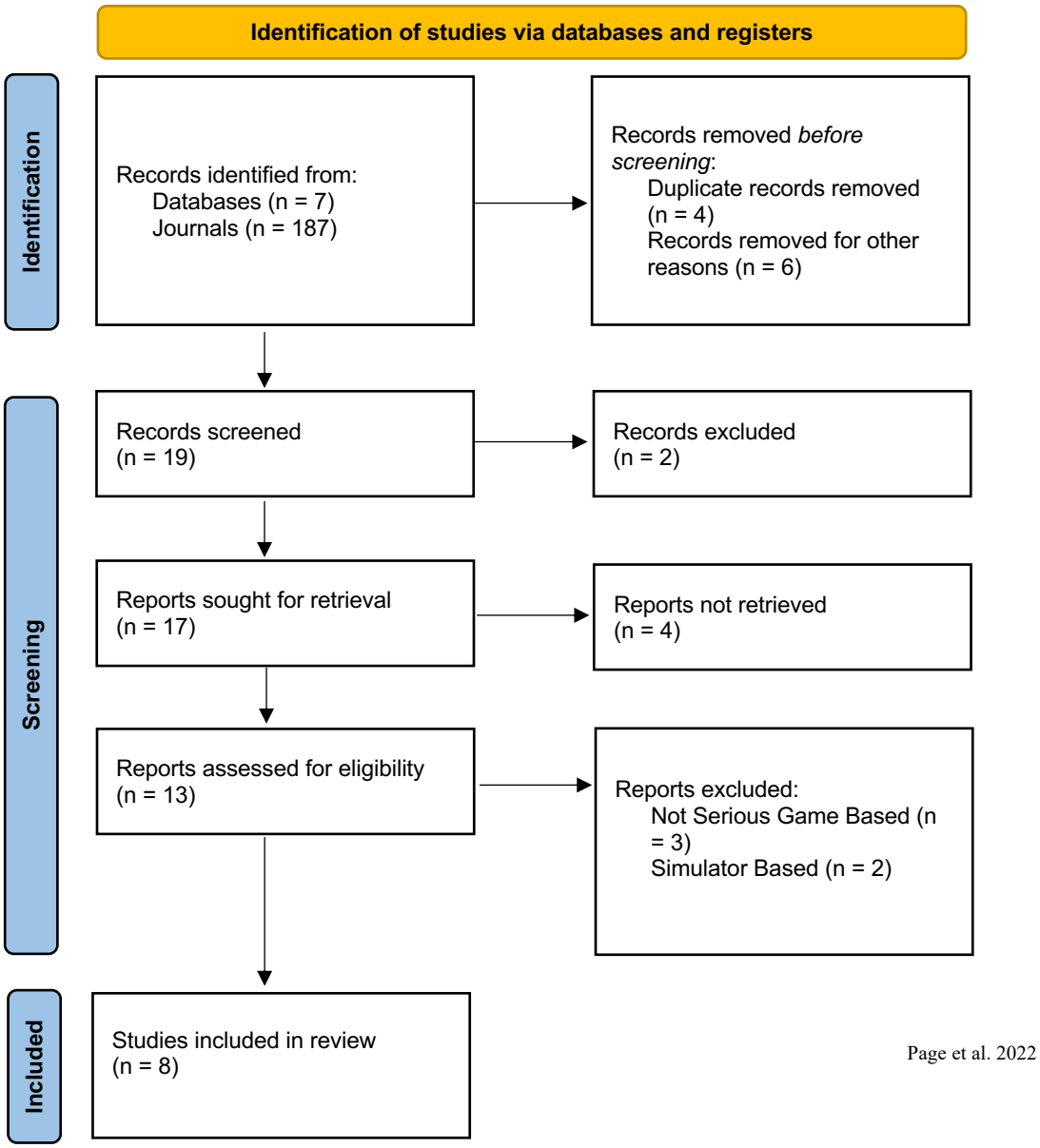
Keywords and related search terms included: *nurse* or *nurs* or *nursing* or *RN* or *medicine* or *medical* or *medic*, *learn* or *learning* or *education* or *educate* or *teach* or *teaching*, *game* or *gamification* or *serious game*, *virtual* or *digital* or *simulation* or *sim* or *fidelity*, *Puzzle* or *escape*

or *escape room*, *effectiveness* or *effect* or *effective*, and *serious game* or *game* or *gamification* or *games* or *playing* or *play* or *gameful* or *gaming*, *med error* or *medication error* or *med err*.

Boolean operator terms of "OR" and "AND" were used to make the database searches more precise. The inclusion criteria were limited to all online journal or source types, primary research articles, quantitative or qualitative research studies, systematic reviews, peer-reviewed articles, English language literature, and articles published between 2007-2022. The exclusion criteria were non-English language literature, publications over fifteen years old, and hard-copy resources due to their inaccessibility. Zotero was used to manage references.

The search yielded 187 publications, and Covidence was used to sort through the retrieved articles. After duplicates were removed, title, abstract, and full-text screening were completed, and eight articles were selected based on the search strategy. A PRISMA diagram is illustrated in Figure 1.

Figure 1. PRISMA Diagram



Medical Errors

Investigating the causes of medication errors in professional nurses and nursing students, Gorgich et al. (2015) administered a questionnaire to 327 professional nurses and 62 nursing students. The results from their cross-sectional descriptive study indicated that medication errors in 97.8% of professional nurses were the result of increased workload, whereas 77.4% of nursing students' medication errors were due to drug calculations. Interestingly, 175 nurses had not

received an education course in the workplace on giving medications, evidencing that it is an expected understanding upon graduation from nursing school (Gorgich et al., 2016).

In a descriptive study conducted in Turkey by Gunes et al. (2020) that examined medication errors made by nursing students, the authors found that voluntary reporting of medication errors is low. Of the 1156 2nd, 3rd, and 4th year Bachelor of Science in Nursing students included in the study, only 72 medication errors were reported in a 28-week period. Of those who voluntarily reported 72 medication errors, the most common reason was treatment delay, which occurred 76.4% of the reported errors, followed by wrong medication at 9.7%, and wrong dose occurring 5.5%. Due to voluntarily reporting medication errors, the authors argue that medication errors likely occur more often and many are going unreported because students are concerned they would receive a failing grade or be labelled incompetent (Gorgich et al., 2016).

As evidenced above, medication errors can have critical outcomes, stressing the importance of reporting so they can be understood and mitigated through environmental changes and educating nurses and nursing students (Kim & Lee, 2020). In a quasi-experimental study with a non-equivalent control group design, Kim and Lee (2020) created a Medication Error Encouraging Training (MEET) program. Students completed a 4-hour education program, which encouraged students to engage in reflective learning regarding the context where the medication error occurred. The researchers recruited 97 BScN students in South Korea, 47 were assigned to the experimental group and received the MEET training, and 50 were assigned to the control group and received the regular curricula. The results demonstrated that the experimental group had a significant increase in confidence in medication safety compared with the control group

(p= .001), supporting increased medication safety through targeted educational intervention (Kim & Lee, 2020).

Determining registered nurses' medication competence is essential as it facilitates the development of nursing education programs and potentiates the mitigation of medication errors (Sulosaari et al., 2011). In their literature review, Sulosaari et al. (2011) highlight the complexities of mathematical and medication calculation skills. They point to the need for the nurse to conceptualize clinical information for medication calculation, utilizing basic arithmetic skills, including addition, subtraction, multiplication and division. Employing these basic skills allows the nurse to develop higher-level skills, including conversions, percentages, dosages calculation, drip factors, and infusion times (Sulosaari et al., 2011).

Simulation-Based Learning

Providing a learning opportunity where students can make mistakes while not harming a patient points to the utility of simulation-based learning. Utilizing simulation-based learning does not negate the learning that traditional didactic lectures can facilitate. In a quasi-experimental design study, Flood and Higbie (2015) recruited 86 American BScN students enrolled in the same nursing course in two separate semesters to compare their knowledge of blood transfusions using traditional didactic lectures and simulations. Students (n=42) enrolled in the winter semester received a standard lecture on hematology properties prior to the simulation. The control group (n=44) students enrolled in the fall semester only received the simulation learning opportunity. Results from the pre/post-test identified the test group’s knowledge scores were significantly higher compared to the control group (p=0.000). The control group students enrolled only in the simulation also had statistically significant post-test results (p=0.003). These results indicate that combining a lecture followed by an applied simulation-based learning

experience significantly improves knowledge. Using simulation-based learning combined with classroom lectures may help bridge the gap between theory and practice and help strengthen cognitive learning (Flood & Higbie, 2016).

Gouifrane et al. (2020) conducted a randomized control trial, which further supports the findings of Flood and Higbie (2016), where the experimental group received blended, computer-based learning alongside traditional classroom learning. In contrast, the control group received only classroom based-learning. The authors intended to understand the development of clinical reasoning skills on blood transfusions among nursing students using a blended learning approach. The (n=32) second-year nursing students in Morocco were randomly assigned to the experimental group or control group. Both groups showed homogeneity ($p>0.05$) regarding age, level of study, term marks, blood transfusion knowledge or experience. Both groups received the same classroom-based education. However, the experimental group also accessed online resources, including web lectures, care procedures, interactive videos, multiple-choice quizzes and online discussion forums. Four weeks after completing the course, the two groups completed a post-test evaluation of clinical reasoning skills related to blood transfusions. Using a Mann-Whitney U-test, the results demonstrated a statistically significant ($p<0.05$) difference in clinical reasoning skills, with the experimental group performing 52.03% better than the control group on the post-test evaluation. The authors highlight how the integration of computer-based learning can help facilitate translation from memorization of knowledge of blood transfusions to knowledge comprehension and utilization in the clinical environment (Gouifrane et al., 2020). This potentiates the improvement of educational delivery to increase nurses' knowledge of blood transfusions and increase the safety of these procedures.

Technology and Learning

With advancements in technology and intergenerational student change, the way students connect with educational material is different compared to 20 years ago. The COVID-19 pandemic has drastically changed how students interact with faculty, course material, and practical experience. COVID-19 has forced education to quickly shift to an online format (Luctkar-Flude & Tyerman, 2021). This change in how students typically engage with instructors, peers, and course material has potentially affected learning effectiveness, self-efficacy, and student motivation.

In their questionnaire-based study, Liaw et al. (2008) found that university students' attitudes toward learning in an online, digital context affect overall learning and learning outcomes. This indicates that creating an online learning format is essential to facilitate a positive learning experience. In their survey-based study of 574 undergraduate business students in Australia, Ferrer et al. (2022) examined students' attitudes toward online learning and the impact on motivation and educational engagement. Notably, the researchers concluded that students' attitude toward online learning is an important mediator in motivation and academic engagement, highlighting the importance of designing online tools that facilitate positive attitudes. The researchers highlighted the importance of developing positive attitudes toward online learning, which correlates with engagement. Additionally, the authors emphasize the relationship between negative attitudes and decreased student engagement (Ferrer et al., 2022). Furthermore, establishing relevance to applying learned knowledge helps enhance motivation, positively impacting learning outcomes (Kember et al., 2008).

Serious Games

Innovative teaching modalities called 'serious games' are gaining popularity in nursing education (Aloweni et al., 2021; Anguas-Gracia et al., 2021; Chen & Tu, 2021; Luctkar-Flude & Tyerman, 2021; Tan et al., 2017; Tyerman et al., 2021). Abt (1987) defined the term "serious game' as, 'the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining" (p.9). Cant et al. (2019) define serious games as a game designed for a primary purpose other than pure entertainment, having an explicit and intentional educational purpose, not amusement. When implemented in undergraduate nursing education, game-based learning provides an engaging, motivating, positive learning experience and encourages critical thinking and reflection in a constructive and safe environment (Aloweni et al., 2021; Gómez-Urquiza et al., 2019). These immersive problem-solving games create an environment that stimulates collaboration, problem-solving, and critical thinking while maintaining a fun and enjoyable learning experience (Korenoski et al., 2021). Correlations between participant motivation, game-based learning, and positive learning outcomes indicate that game-based learning can aid in maintaining or improving motivation: students perceive escape rooms as an incentive to learn without outside intervention (Vidergor, 2021).

Gamification, often used synonymously with serious games, uses game-based scenarios implemented in learning environments to enhance learning, such as knowledge and engagement (Poondej & Lerdpornkulrat, 2016). Gamification is also used in interdisciplinary collaborative practice as it can helps foster interprofessional communication (Hawkins et al., 2020). Gamification enhances team cooperation and dynamics by presenting real-world problems and

requiring participants to collaborate to create solutions (Hermanns et al., 2017). Gamification of transmitting knowledge to learners establishes a student-centred approach that puts the learner in control of their environment, ultimately controlling their learning experience (Wise et al., 2018).

Using the proper terminology and understanding the supporting facets of gamification are essential. It facilitates a clear understanding and clear dialogue in the literature. Immersive simulations are real-life replications of clinical situations that involve participants' senses, emotions, behaviours, and thinking that mimic the perception of the real-world environment within an educationally designed scenario (Cant et al., 2019).

Virtual reality uses computer technology to create an interactive world that does not physically exist but is dependent on computer software and creates an experience of spatial awareness (Cant et al., 2019). Using virtual reality can be very beneficial. As it is based on computer technology, an educator or software developer can design the interactive world based on specific content they want the learner to experience. The environment can replicate any real-world environment, training healthcare professionals in a realistic way. Limiting factors for creating virtual realities involves cost (equipment and human power) and computer design expertise.

Virtual Simulation

Cant et al. (2019) define virtual simulation as "an interactive education process used in health care disciplines, where real people operate screen-based simulated systems that portray people or training equipment and devices" (p. 27). These virtual simulations can be used to facilitate the ideal learning environment that targets specific learner outcomes as decided by the educator.

Of importance to educators, teaching strategies should meet the needs of the learner (Johnston et al., 2015). Generation Z learners, born between 1997 and 2012, have been exposed to digital technology their whole lives and are digitally literate, requiring rapid access to information within an online environment (Kennedy & Fox, 2013). This supports the transition toward Web-based learning (Liaw et al., 2008). Through need and learner preference, nursing educators have increased the use of serious and virtual games in undergraduate nursing education. In-person escape rooms offered in a virtual environment are now being explored (Vestal et al., 2021). Similar to serious games, virtual games are completed within a virtual environment, often generated on a computer. Cant and Cooper (2017) define virtual simulation as, "…goal-based digital simulations that take place via a computer screen. Use of multimedia (video, text, voice, and feedback) provides an interactive Web-based educational experience" (p. 46).

Due to the restricted clinical environment due to the COVID-19 pandemic, virtual games have gained recent popularity in healthcare education which has become a focus of current nursing research. In a 2022 cross-sectional, exploratory study of 12 medical students in Singapore, researchers looked to determine students' perception of serious virtual gaming. They concluded that students expressed it as a fun and enjoyable activity, which helped increase their internal motivation (Tan et al., 2022). This was supported by Verkuyl et al. (2022), who used open-ended questions through qualitative feedback to determine the reception of virtual games for nursing education. Of the 568 respondents, 87.1% reviewed the games as positive, which improved the respondents' desire to engage with the game further (Verkuyl et al., 2022).

In a Canadian multisite and multistage randomized controlled trial, a virtual simulation game was used as a presimulation preparation prior to an in-person live respiratory distress

simulation-based experience for undergraduate nursing students (Luctkar-Flude et al. (2021). The study involved three components: virtual simulation game development and review, useability testing, and a post-virtual simulation game implementation survey. The first two stages had three faculty members and three nursing students play the virtual simulation game, where they provided written feedback and completed a usability survey. The remaining third stage involved fourth-year undergraduate nursing students (n=92) enrolled in a critical care nursing course. The students were randomly enrolled in either a case study or a virtual simulation game. After completing their allotted group, the students filled out the Class Room Instructional Support Perception Scale (CRISP), a 12-item validated survey that measures three subscales; learner perceptions of usability, engagement, and impact on learning of a given educational intervention. Each item was rated on a Likert scale from 1 to 5. Usability findings indicated that the virtual game was easy to learn, participants knew what to do, and no technological problems were identified. These results continued among the 92 nursing students who rated the virtual simulation games as easier to use ($p=0.011$), more engaging ($p=0.005$), and contributed more to their learning ($p=0.021$) when compared to the case study group. The researchers strongly support the use of virtual simulation games as a way to promote self-regulated learning, strengthen knowledge, decrease anxiety, and improve preparation and performance during an in-person simulation (Luctkar-Flude et al., 2021).

There is a strong relationship between student enjoyment, improved efficacy, and gaining knowledge as positive markers of serious games (Backhouse & Malik, 2019; Korenoski et al., 2021; Lee, 2015; Stringfellow, 2021; Tan et al., 2022). A clustered, randomized controlled trial by Tan et al. (2017) implemented a virtual game where students completed multiple mini-challenges based on learning objectives and problem-solving skills surrounding blood

transfusions. The researchers recruited 103 second-year undergraduate nursing students in Singapore who were randomly assigned to the experimental or control groups. The experimental group undertook a blood transfusion virtual game on the computer, while the control group was waitlisted to complete the game after the collection of the post-intervention data. Post-test knowledge and confidence scores for the virtual game experimental group significantly improved compared with their initial pretest ($p<0.001$) and to the post-test scores of the control ($p<0.001$). The authors also noted no significant difference ($p=0.11$) between groups on post-test performance mean scores. The study provides evidence of the positive effects of gaming on student learning and knowledge development related to the safe administration of blood transfusions (Tan et al., 2017).

Escape Room Learning

Escape rooms are proving to be an effective educational tool in healthcare education. Backhouse and Malik (2019) completed a quasi-experimental descriptive study of third-year medical students (n=19), exploring the effectiveness of an in-person escape for knowledge acquisition, insights, skills and confidence in applying knowledge. Results indicate that learners' perceptions of escape rooms were highly favourable, further validating previous research on the effectiveness of educational escape rooms (Backhouse & Malik, 2019; Garwood, 2020; Vidergor, 2021).

Within nursing education, Stringfellow (2021) completed a descriptive study involving undergraduate nursing students' (n=10) perceptions of educational escape rooms. Using an 8-item 5-point Likert scale, participants preferred escape room learning to traditional learning environments. Participants prefer active learning to the traditional learning environment and

perceived escape room learning helped meet learning objectives (Stringfellow, 2021). The researchers did not provide all the questions they asked participants.

This result was further validated by a US study by Gómez-Urquiza et al. (2019) using a cross-sectional descriptive study exploring nursing students' opinions and motivation using in-person escape rooms. Involving undergraduate nursing students (n=103), results revealed participants perceived escape rooms to enhance knowledge acquisition, improve motivation/engagement and maximize a positive learning environment (Gómez-Urquiza et al., 2019).

Nursing researchers have explored in-person escape rooms, primarily focusing on patient safety priorities. In 2019, Zhang et al. (2019) surveyed 130 first-year medical residents in the United States after completing an escape room serious game where learners were required to identify reportable patient safety priorities. Data was collected using a five-item Critical Incident Questionnaire post-game exploring critical thinking and reflection, learning preferences, and recognizing ideas for future adaptations and improvement for future iterations. Results indicated that learners felt highly engaged and immersed in the learning experience, and the experience fostered effective communication and helped participants learn to establish team roles (Zhang et al., 2019). Of interest, Aloweni et al. (2021) conducted a descriptive qualitative evaluation and feedback improvement study implementing face-to-face semi-structured interviews with RNs (n=11) in an acute tertiary hospital inpatient setting in Singapore following an in-person blood transfusion escape room. The researchers evaluated RN’s experiences using serious games to develop skill competency and improve the quality of learning. Results indicated that participants valued this form of learning and found it engaging and stimulating learning. The researchers strongly suggested that more research was needed to improve accessibility, intuitiveness and

interface specific to escape room learning pedagogy to enhance learner outcomes (Aloweni et al., 2021).

Virtual escape rooms (VER) follow similar attributes to in-person puzzle escape rooms but within a digital environment (Pozo-Sánchez et al., 2022). VERs are goal-oriented games, proceeding in a linear or non-linear progression, depending on the game's complexity and learning level. Designed to achieve educational goals, they are implemented on a screen-based platform. VERs are highly innovative, with limited research exploring effectiveness on learning outcomes to date. The supervising researcher created a novel learning experience called a virtual interactive puzzle escape room (VIPER), which incorporated an interactive component within the digital environment.

Learner Outcomes Using Serious Games

Several contributing concepts to learning outcomes are highlighted below. These concepts are influential in establishing effective learning environments for students. If integrated within a learning environment, these concepts have the potential to improve teaching modalities for medication and blood administration.

Self-Efficacy

Self-efficacy is an important concept defined as an individual's belief in their ability to successfully execute behaviours necessary to complete a desired outcome (Bandura, 1997). This draws on a practitioner's belief that if they believe they are competent and capable of performing medication calculations properly, they will be more likely to be correct. Tailoring the educational approach to support nursing students' self-efficacy in executing medication calculations can positively affect patient safety (Williams & Davis, 2016). Although perceived self-efficacy is

challenging to validate, it is essential to measure learners perceived value to learner of new educational innovations.

In a quasi-experimental pretest, post-test design (Lee, 2015), the researcher explored perceptions of 135 American undergraduate students' perceived self-efficacy when exposed to passively watching a digital game that intentionally failed to reach the game objective, passively watching a game that succeeded or interacting with a serious game. The gameplay objective was mobilizing support against the government's anti-bubble gum law. Study outcomes indicated that participants engaged with interactive games reported higher levels of self-efficacy than participants who passively watched gameplay ($p=0.039$). The researcher suggests the benefits of undergraduate students' engagement with serious interactive games rather than passive observation. Chen and Tu (2021) further supported these findings using a quasi-experimental pretest/post-test design in a study of 510 junior high school students. The study explored knowledge acquisition following: (a) conventional learning; or (b) through a digital game; or (c) learning through a digital game and competing with classmates. Results suggested improved self-efficacy for both groups who engaged with the digital games, while those who engaged with the digital game and were competing with classmates had the greatest improvement ($p<0.001$). Those who studied digital game-based learning achieved improved learning when compared to those who learned from a conventional learning approach. The students in the digital game and digital game with competition cohorts demonstrated lower anxiety and depression, which resulted in higher self-efficacy and improved learning performance (Chen & Tu, 2021).

In their systematic review of escape rooms implemented in multiple educational settings, Veldkamp et al. (2020) concluded that in-person escape rooms support positive team dynamics, including collaboration and problem-solving. Teamwork and collaboration are essential for the

successful and timely completion of the escape room (Veldkamp et al., 2020). This is a fundamental aspect of nursing interprofessional healthcare practice. Providing opportunities to engage in positive team dynamics within an interactive escape room environment can further facilitate effective teamwork within the healthcare environment, supporting patient safety and improving patient outcomes (Zhang et al., 2019).

Engagement

Employing gamification as an educational tool may foster advanced knowledge and skill acquisition and development and generate a deeper understanding of key principles within a topic, mainly when dealing with complicated issues normally taught by traditional didactic education (Brom et al., 2011). Gamification immerses learners into stimulating and thought-provoking environments that cognitively engages the learner, encouraging creative thinking and critical thinking to solve complex issues.

A systematic review was completed by Hookham and Nesbitt (2019) sought to clarify the definition and measurement of engagement in serious games. The authors identified that *engagement* referred to use; the player is *engaging* in or with an activity or game; engagement referring to a player state, the player is "*engaged*"; and engagement refers to the property of a game or object to be "engaging"' (Hookham & Nesbitt, 2019, p. 7). Student engagement is an important factor that positively impacts learning outcomes (Carini et al., 2006; Hamari et al., 2016). Gamified learning environments offer an opportunity to increase student engagement, as student engagement is observed when it increases during interactive experiences (Stringfellow, 2021).

Poondej and Lerdpornkulrat (2016) explored gamification to increase student engagement in learning. They used a quasi-experimental non-equivalent-control group design

with 577 undergraduate students in 6 separate literacy skill classes in Thailand. The experimental and control groups were taught the same content, although the experimental group received the information through gamification. Students assigned to the intervention group were exposed to gamification concepts such as missions, leaderboards, scoring systems, earning experience points, and experience levels within the learning material. Classes were designed as 'missions' where students would complete 'objectives' and depending on the accuracy, would earn varying levels of experience points that would 'move them up' relative to their peers. The control group was not exposed to any gamified concepts. The results indicate that students in the gamified group had higher levels of engagement in learning, which lends support to gamification in learning, aiding in student engagement (Poondej & Lerdpornkulrat, 2016).

A cross-sectional descriptive study by Hamari et al. (2015) examined the impact of engagement, challenge and skill, and immersion on learning within game-based learning environments. The researchers conducted this study in two separate settings with two separate games. The first setting involved 11 separate classrooms across the United States in secondary schools with 134 high school students in Grade 11. These students completed a puzzle-style game called *Quantum Spectre*. Students were to direct a laser beam at a target using a combination of flat and curved mirrors, lenses, beam-splitters, and other optical devices. When the correct colour laser had reached all the appropriate targets, a level would be complete, and the students would move to the next level. The second setting was among 40 undergraduate mechanical engineering students in the United States who played a game called *Spumone* throughout a 15-week semester. The objective of this game was to direct a 2-dimensional vehicle through a subterranean, simulated world, relying on principles learned in their engineering dynamics course. Post-gameplay, participants completed a survey. Applying Structural Equation

Modeling results indicated that educational virtual gamification could effectively engage students, demonstrated by increased levels of engagement, such as high concentration, interest and enjoyment. Results indicate that engagement in gaming has a positive effect on learning ($p<0.05$). Alternately, immersion in the gaming environment does not significantly impact learning. Serious games present an opportunity to increase learning engagement, potentially leading to improved knowledge development (Hamari et al., 2016).

Knowledge

Knowledge is a continually contested debate. Depending on an epistemological stance, the meaning and formation of knowledge can hold different epistemologies and ontologies. From a pragmatist perspective, described by Peirce & Hetzel (1878), the pragmatic approach recognizes knowledge about an object to, "consider what effects, that might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object" (p. 6). In essence, this conceptualization allows the individual to formulate knowledge and come to practical and useable conclusions.

Knowledge, teaching, and learning are intimately connected and essential to effectively utilizing knowledge from classroom experience to real-world applications (Novak, 2010). Nurse educators need to apply teaching and learning principles that foster knowledge development and connection through active learning strategies throughout nursing education (Getha-Eby et al., 2014). This knowledge mobilization will be used in clinical environments.

In a quasi-experimental pre/test post/test study, researchers in the United States implemented two in-person escape rooms for pharmacy students (n=22) to evaluate player knowledge of toxicology principles (Korenoski et al., 2021). Results of Escape Room 1

(acetaminophen toxicity) revealed four of 22 students (18%) received a passing grade on the pretest, and 18 of 22 (82%) received a passing grade on the post-test. Results for Escape Room 2 (serotonin syndrome), 0 of 22 students (0%) received a passing grade on the pretest, and 15 of 22 (68%) received a passing score on the post-test. The authors did not provide p-values for the pre/post-test. Findings indicated that in-person escape rooms facilitate increased knowledge acquisition and utilization while positively affecting student engagement. The researchers support the use of serious games and suggest that gaming may aid in educating other healthcare professionals, not just pharmacy students (Korenoski et al., 2021).

Motivation

Motivation is defined by Gopalan et al. (2017) as "the process to make a start, guides and maintains goal-oriented behaviours. It leads individuals to take action to achieve a goal or fulfil a need or expectation" (p.1). Motivation and the learning process are very connected, where motivation is an important attribute connected to either success or failure in the pursuit of learning (Gopalan et al., 2017; Tohidi & Jabbari, 2012). Motivation has two concepts; intrinsic and extrinsic motivation. Tohidi & Jabbari (2012) define intrinsic motivation as "…driven by an interest or enjoyment in the task itself, and exists within the individual rather than relying on any external pressure" (p. 821). Intrinsic motivation is important in learning as it helps explain why an individual seeks learning pursuits. Interestingly, intrinsically motivated learners often believe their learning results are due to their effort, believe they are the agents responsible for achieving their results and are interested in the presented topic (Tohidi & Jabbari, 2012). Extrinsic motivation influences a person's external factors (Tohidi & Jabbari, 2012). Examples of extrinsic motivation include money, punishment, or competition.

The importance of motivation in learning cannot be understated. A two-sample questionnaire-based study by Kaše et al. (2018) examined the psychological process that influences digital skill development for older adults when being taught by younger adults. The researchers hypothesized that intrinsic and extrinsic motivation are strong drivers of skill development in young and old adults. Comparing young (n=457) (average age in years 27.5, SD=9.7) to older learners (n=293) (average age in years 64.7, SD=7.9), participants engaged in a week-long initiative where young mentors taught older learners to computer and other digital devices skills. The variables were intrinsic and extrinsic motivation, self-efficacy, positive affect and skill development, and all were measured using a 5-point Likert-type scale. The study findings indicated that both intrinsic and extrinsic motivation are important mediators of digital skill acquisition and learning (Kaše et al., 2019). This parallels the findings of Tan et al. (2017), who conducted a randomized control trial to describe developing and evaluating a serious game to improve nursing students' knowledge, confidence and performance in executing blood transfusion. The authors highlighted motivation as important in learning and how the experimental group valued the serious game in enhancing motivation to learn and understand the material (Tan et al., 2017). Of note, Kaše et al. (2018) point to intrinsic and extrinsic motivation differed between age groups. Older learners relied heavier on extrinsic motivation, such as obtaining a goal, like making a certain amount of money for working. In contrast, the younger group relied more on intrinsic motivation, such as finding meaning or gratification when completing an objective (Kaše et al., 2019).

Having a form of learning that promotes positive responses and increases students’ desire to play can provide positive implications for repeated practice with medication calculations, which could positively affect and decrease medication errors. Medication calculations potentiate

anxiety in nursing students, which only increases when students are expected to learn highly skilled practices such as blood transfusions (Chernomas & Shapiro, 2013; Owegi et al., 2021). Nursing educators must help mitigate student anxiety to help facilitate optimal learning for the safety of the students and patients upon graduation (Quinn & Peters, 2017).

As indicated above, fostering an educational environment that supports engagement, self-efficacy, and motivation could positively impact knowledge utilization while lowering anxiety and improving learning performance (Chen & Tu, 2021; Kaše et al., 2019; Korenoski et al., 2021; Poondej & Lerdpornkulrat, 2016). Utilizing virtual interactive puzzle escape rooms as serious game-based learning presents an opportunity to effectively execute complex clinical interventions by increasing students' engagement, self-efficacy, and motivation while decreasing anxiety, resulting in fewer medication errors and overall patient well-being.

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Chapter 3: Reflexivity Statement, Philosophical Underpinnings and Conceptual Framework

Reflexivity Statement

During my undergraduate nursing education, I received negative feedback on an essay I had written for a class assignment. I went to my professor to better understand and learn from their feedback. They told me, "This was not an assignment to expand ideas and develop new thoughts, I wanted you to simply answer the posed question." I have never been able to forget this statement because I *want* to expand ideas and develop new thoughts! I want to help foster a culture of research, exploration and advancing knowledge in nursing through education. My goal is to become a professor in nursing and inspire my students to think curiously, critically and creatively – to identify problems and generate novel solutions.

In my career to date, I have worked as a Registered Nurse (RN) in Intensive Care Units (ICU). Blood transfusions are an integral component of the work of any critical care practitioner, and critical care RNs administer or assist in administering blood transfusions on a routine basis. In my experiences with blood transfusions, I was fortunate to have had significant support from experienced nurses to learn about transfusion procedures and potential adverse reactions. In one clinical encounter in a cardiovascular ICU, my patient developed a massive internal bleed and required many blood transfusions. My colleagues and I skillfully provided the necessary blood resuscitation efforts, and the patient survived. Conversely, I have also witnessed a fatal transfusion reaction during my clinical work. It was an exceptionally distressing situation for all healthcare staff involved and the patient's family members.

I want to use my passion for teaching to address the gap in education on blood transfusions and their reactions. The virtual education environment provides a fun, engaging and

versatile method of teaching nursing students. It is an educational modality that I can carry forward to other areas of educational interest.

I am a cis-gendered, heterosexual, financially privileged, able-bodied, neuro-typical, white male settler who views and is viewed from these vantage points. I am aware that these modes of identification will impact how I conduct my research work. As an example, when conducting Qualitative research, this positionality may limit my ability to develop inferences thus narrowing the quality criteria. To prevent this, I routinely attend various learning opportunities, collaborate with researchers whose positionality is different from mine, and self-reflect continually throughout the research process and my personal life.

Philosophical Underpinnings

The research was conducted using a mixed-methods approach where the conceptual model is pragmatism, which is compatible with mixed-methods research (Hall, 2013). The term pragmatism was initially conceived by William James in 1898 when he addressed the Philosophical Union of the University of California at Berkley (Malachowski, 2013). James expanded on the work of Charles Sanders Pierce, specifically on the 'principle of practicalism' (Malachowski, 2013). Another contributor to pragmatism was John Dewey. Dewey argues that when inquiry is confined to a prescribed conceptual schema, solutions are not novel or unexpected. Instead, when the problem guides the process, unique and problem-specific solutions are established (Dewey, 1997). Dewey was particularly interested in education because the knowledge students learn can be applied to real-world problems, potentially leading to real-world solutions (Cherryholmes, 1992).

Many research traditions, such as Positivism, Empiricism, Phenomenology, and/or Interpretivism, attempt to rectify problems, relying heavily on preconceived schemas to do so

(Cherryholmes, 1992). Research governed by the pragmatic approach seeks to elucidate meanings by attempting to understand the consequences/outcomes (Cherryholmes, 1992). The pragmatic approach lends itself to mixed methods research in that it moves between inductive and deductive reasoning (Morgan, 2007). At its core, pragmatism is a philosophical approach where single practical maxims are less concerned than the total or outcomes of single practical outcomes, which determine how an individual acts within the world (Malachowski, 2013). Pragmatism fosters an intimate relationship between theory and practice, which potentiates a cyclical nature between the two, where one can help foster the development of the other (Malachowski, 2013).

The pragmatic approach begins by converting observations into theories and assessing these theories through action (Morgan, 2007). As Peirce & Hetzel (1878) described, the pragmatic method is to "consider what effects, that might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object" (p. 6). This conceptualization and movement between inductive and deductive reasoning allow the researchers to come to practical and useable conclusions.

Mixed-method research is 'the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study' (Johnson & Onwuegbuzie, 2004, p. 17). Mixed methods draw on both strengths of qualitative and quantitative research while minimizing the weaknesses of isolating quantitative or qualitative data from either type of research (Johnson & Onwuegbuzie, 2004). This research intends to develop a functional, useable, and applicable modality to improve nursing education. Mixed-methods research provides an appropriate methodology where the

developed techniques' usability is similar to what is used in practice (Johnson & Onwuegbuzie, 2004).

Utilizing mixed-methods research as a component of the philosophical underpinnings is imperative to the success of this project. Obtaining the quantitative GAMEX in isolation would weaken the inference quality. Similarly, with only obtaining qualitative data, the ability to ascertain conclusions would be limited. VIPER is such a novel educational modality; it is paramount that the encompassed experience is understood. The qualitative data will provide context to the quantitative data, elucidating why participants provided their respective quantitative responses. Once student experience is thoroughly understood, the researchers can utilize this information to improve the gameful experience. With both qualitative and quantitative information, the researchers would be adequately informed to make adjustments to VIPER.

Theoretical Framework

The theoretical framework used in this research is the National League for Nursing (NLN) Jeffries Simulation Theory (Jeffries, 2005; Jeffries et al., 2015) (Figure 2). This theory is ideal for this research because it directly addresses the cross-section between education and simulation, including the specific use of computer-based simulations (Jeffries, 2005). It builds on several theoretical perspectives, such as learner-centred, constructivist, and sociocultural perspectives of learning (Lavoie et al., 2018). It is an instructional design theory situated in a teaching paradigm offers direction for simulation design and implementation within nursing education (Lavoie et al., 2018).

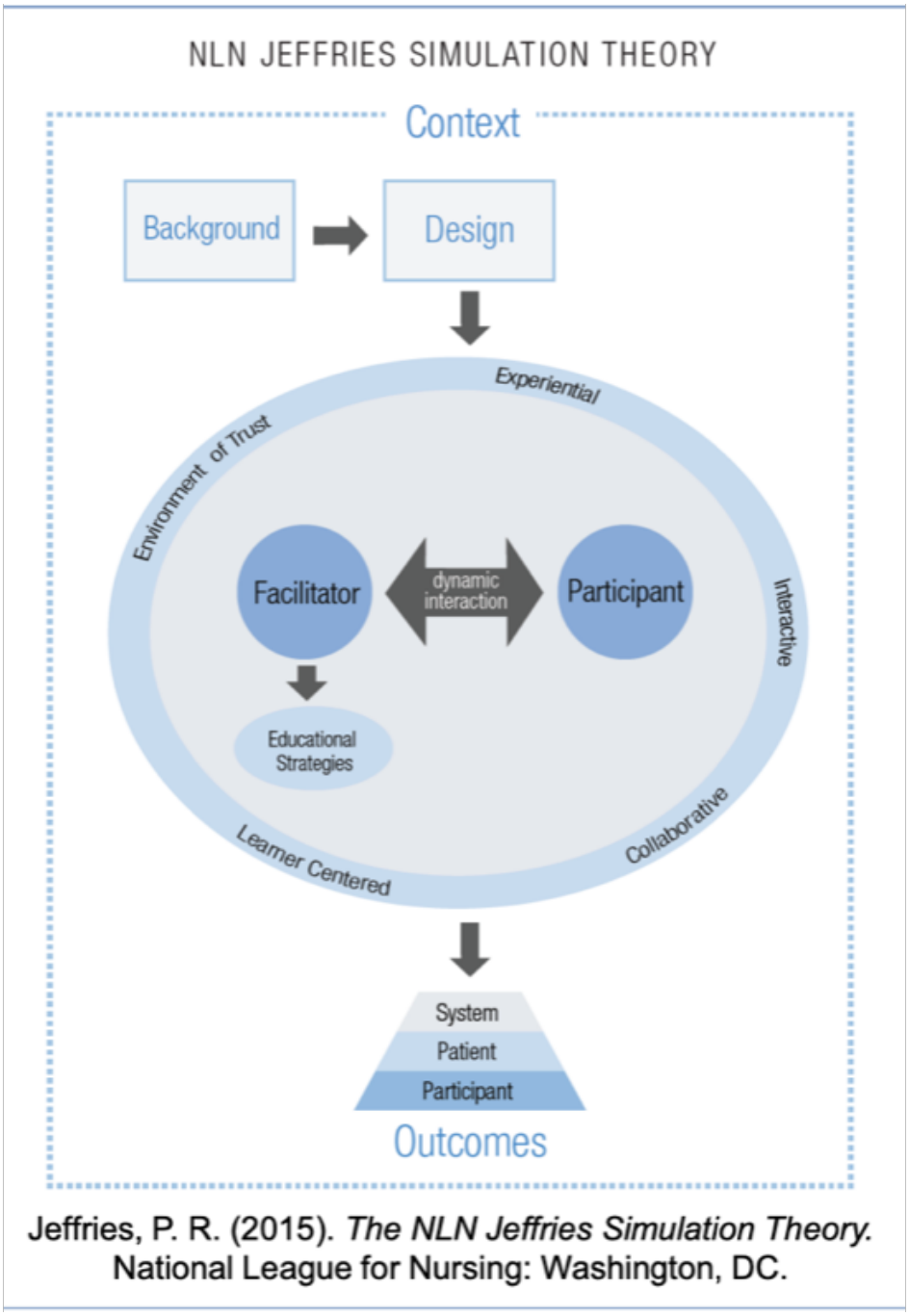
This theory has six components: the background, the design, the simulation experience, the facilitator and educational strategies, the participant and the outcomes. Each component is

pivotal to the success of the simulation, contributing a different aspect to the simulation (Jeffries et al., 2015).

The background incorporates the simulation's goals and expectations that help determine the design of that simulation. Notably, the background also recognizes the simulation resources and how those resources, such as time and equipment, will be appropriated within the simulation. The quality of simulation design is essential, as a properly designed simulation can facilitate achieving successful learning objects. The design guides how to implement the specific learning objectives within the simulation development, where learning scenarios are contextually appropriately created, and problem-solving scenarios are adequately complex. The simulation experience includes the interactive [virtual] simulation and the physical environment the learner will participate in the simulation, which is interactive, collaborative, and learner-centred (Jeffries et al., 2015). The participant needs to believe the experience they are participating in is authentic and suspends disbelief, which aids in promoting engagement (Jeffries, 2005). The facilitator and educational strategies are active interactions between the facilitator and participant. During in-person simulation, the facilitator can adjust the simulation's progression to accommodate the participant's specific learning needs. During the simulation experience, the interaction between the facilitator and participant becomes one where the facilitator establishes a trusting, safe, and accepting environment where the participant feels comfortable asking questions and addressing issues the participant might be experiencing. The participant attributes such as gender, age, self-confidence, preparedness, and level of anxiety also affect the simulation learning experience (Jeffries et al., 2015). Some of these are modifiable, whereas others are not. This emphasizes the importance of the facilitator and participant relationship. Finally, the simulation outcomes can be separated into participant, patient, and system. It is important to recognize that the participant is

learning information to work within a system where the patient is receiving care (Jeffries, 2005; Jeffries et al., 2015). Outcomes from the participant's perspective can incorporate knowledge development, skill performance, learner satisfaction, critical thinking, and improved self-confidence (Jeffries, 2005). Outcomes of a simulation need to be recognized within the context they are learned, which has implications for the patient and organizational/system outcomes (Jeffries et al., 2015).

Figure 2: NLN Jeffries Simulation Theory



This conceptual theory should benefit the researchers within the simulation design, implementation and evaluation as described (Jeffries, 2005). Utilizing the NLN Jeffries Simulation Theory can help facilitate the optimal learning experience for the participant while

simultaneously aiding in the development of the best possible virtual simulations. It will also help students learn and become proficient practitioners.

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Chapter 4: Methods

Research Design

This research involved a quasi-experimental explanatory post-test design. Quasi-experimental design research does not involve randomly assigning participants to experimental and control groups but is conducted without randomization (Polit & Beck, 2021). In this research design, information was collected from participants after completing the VIPER intervention. During a single phase participants completed the GAMEX questionnaire first, followed by the open-ended questions. For this study, quantitative data was given the dominant status.

The quantitative portion of the research study assesses participants' experience of the virtual interactive puzzle escape room (VIPER) using the Gamefulness Experience Scale (GAMEX) (Eppmann et al., 2018) (Appendix E). The study's independent variable was the completion of the VIPER by participants. The dependent variables were perceived *enjoyment, absorption, creative thinking, absence of negative effects,* and *dominance* measured after the intervention.

The qualitative portion of the study involved participants completing open-ended questions after completing the GAMEX. Consenting participants wrote their responses in text boxes to answer three questions at the end of the GAMEX (Appendix E). The qualitative data provided further insight into the 'students' experience and perceived effectiveness of the VIPER Blood Administration game.

Setting

The single-site setting for this study involved participants enrolled in a BScN, third-year medical-surgical course at a university in Ontario, Canada. As a course requirement, all students enrolled in the fall NSG3105 course completed the VIPER blood transfusion game and GAMEX

scale. After completing the VIPER, students were invited to participate in the study and share the results of their GAMEX scores. Students participating in the survey were entered into a lottery for one of ten $25.00 Starbucks gift cards.

Sampling

Participant recruitment utilized convenience sampling which involves recruiting the most conveniently available participants of the targeted participants (Polit & Beck, 2021). Non-probability convenience sampling was used, recruiting all eligible third-year undergraduate nursing students. Non-probability convenience sampling utilizes the most conveniently available people as participants (Polit & Beck, 2021). This sampling technique was the most ideal for this research because the students are being studied and available at the university where the researcher is completing their studies. The sample size was calculated using the University of California, Los Angeles (UCLA) G*Power calculation software for a one-sample t-test based on the inputted data: $d=0.5$, $\alpha = 0.05$, power=0.95 which resulted in a required total sample of 34 (Faul et al., 2007). If 120 students are eligible, an anticipated response rate of 30%, the number of students likely to enroll is n=36, surpassing the required sample dictated by the G*Power software (Faul et al., 2007).

Qualitative data collection utilized a convenience sampling approach whereby the most readily available people will participate by answering the open-ended questions at the end of the GAMEX (Polit & Beck, 2021). There was no recommended sample size for the qualitative portion of the research study (Polit & Beck, 2021). However, a thorough literature search of studies using open-ended questions to understand the outcomes of the intervention ranged from 8 to 10 participants within the data sample size (Buterakos & Keiser, 2021; Stringfellow, 2021). Since the sample size for qualitative data is not strictly established (Polit & Beck, 2021) and

previous research has been completed with few interview participants, a minimum sample size of eight participants (n=8) was required.

Inclusion criteria for this study include: (a) registered as a full-time or part-time student enrolled at the University of Ottawa in the BScN program; (b) enrolled in the 2022 fall Medical-Surgical Nursing course (NSG3105) English stream; (c) able to speak and write in English, and (d) has completed the hematology blood transfusion coursework for this class. Students unable to read and write in English (French language students) are excluded from this study as the GAMEX tool is only available in English, and the tool author did not give permission for translation.

Third-year nursing students are an ideal sample population as they are familiar with nursing responsibilities for blood transfusions and have completed various courses/labs focusing on medication calculations. Additionally, as administering blood transfusions is an essential nursing skill, students was able to utilize the learning from the VIPER game in clinical practice and for the remainder of their education.

Recruitment

Recruitment of participants in the University of Ottawa BScN program included the following:

Quantitative:

1. A recruitment poster (Appendix H) describing the study, research question and inclusion criteria was posted on the course Brightspace Announcements page.
2. The study package, including (a) a Letter of Information (Appendix C) and (b) Consent (Appendix D) was posted on the course Brightspace Announcement's page for students to review before the onset of the study.

3. Two weeks before the start of the study, the researcher conducted a short three-minute presentation during the third-year medical-surgical course (NSG3105) to explain the purpose of the research and answer any study questions.

Qualitative:

1. Upon completing the GAMEX tool, participants were given the opportunity to answer three questions at the end of the GAMEX portion of data collection (Appendix A).
2. The VIPER Blood Transfusion game link and online GAMEX survey tool was posted in the Brightspace Week 7 Hematology lecture folder as part of the course. A link to the Study Package was also available in the lecture folder.

Consent

At the end of the GAMEX online tool, participants were asked if they wished to participate in the study. By clicking 'Yes, I agree to participate in the study, the participant provided online Letter of Information and Study Consent (Appendix C and D). Consent from the quantitative portion of the study and implied consent by voluntarily answering the questions will apply to the qualitative part of the study.

Incentive

Upon completing the GAMEX questionnaire and three open-ended questions, participants copied and pasted a URL that took them to a new and separate SurveyMonkey survey. This new survey had a single open-ended response question that asked participants to submit their email. Participants' emails were used to be entered into a draw to win one of ten $25.00 Starbucks gift cards. These electronic gift cards were sent to the winners via email.

Intervention

Escape Rooms have gained popularity as a form of gamification in healthcare education (Adams et al., 2018; Connelly et al., 2018; Gutiérrez-Puertas et al., 2020). The VIPER Blood Transfusion game is a virtual escape room that was designed and developed by a team of E-Learning Specialists and content experts based on gaming theory, cognitive load theory, nursing theory and evidence-informed practice guidelines. Gaming theory targets the link between decisions and outcomes (Roungas et al., 2019). Cognitive load theory aims to use the knowledge of human cognition to guide design principles (Sweller, 2011). Following established learning outcomes, participants completed assigned nursing tasks by solving puzzles. The scenario was designed around a complex clinical intervention to develop clinical reasoning and judgment skills. This includes medication administration, dosage calculation, blood product administration, patient safety principles, infection control, patient education and communication. Replicating a natural clinical environment using 360 images, learners engage in a series of critical-thinking nursing tasks specific to drug calculations and blood administration. The VIPER incorporates best-practice guidelines, principles of infection control, assessments, prioritization, and skills application.

The VIPER game begins with an optional brief tutorial on how to play the game. Learners are then led to a medical-surgical unit and were assigned a patient who requires a blood transfusion. During the scenario, learners solve a series of puzzles, including (1) weight-based medication calculations, (2) identification of blood compatibility, (3) management of a transfusion reaction, and (4) adherence to the rights of medication administration. Using a combination of linear and branching escape room design principles, learners must solve each puzzle before they can complete specific tasks.

The VIPER game can be played individually or within a group. For this study, individual gameplay was required. Players could take as long as they wanted to complete the game. A certificate of completion was provided at the end of the game.

Data Collection

Data collection included three tools: (1) the Gamefulness Experience Scale (GAMEX) (Appendix E), (2) the sociodemographic survey, and (3) open-ended questions. The GAMEX scale was available to all students to complete on Brightspace. Completion of the GAMEX scale is a requirement for the course. At the end of the GAMEX scale, participants were given the Letter of Information and Consent for review (Appendix C and D). Students were asked to indicate their decision regarding study participation. The question "Do you agree to participate in the study?" will have two options:

Yes, I agree to participate in the study and share my GAMEX results

No, I do not agree to participate in the research and will not share my GAMEX results

Consenting participants then proceeded to the study's sociodemographic survey (Appendix G). Students who declined participation in the study were taken to a Thank You page.

Gameful Experience Scale (GAMEX)

Quantitative data was collected using the GAMEX tool with permission from the authors (Appendix F). The GAMEX tool measures six dimensions of the gameful experience, including; *enjoyment* (α = .96), *absorption* (α = .91), *creative thinking* (α = .88), *activation* (α = .87), *absence of negative affect* (α = .85), and *dominance* (α = .84) (Eppmann et al., 2018). The reliability of the GAMEX scale has a Cronbach alpha of 0.89, indicating a high-reliability (Eppmann et al., 2018). The scale is only available in English. The researchers did not receive permission to translate the scale into French.

The researchers received permission to use the tool from the tool creators (Appendix F). It was administered in English, as time constraints require validation to translate the GAMEX into French.

Sociodemographic Survey

The sociodemographic survey was available to consenting participants via Survey Monkey upon completion of the GAMEX scale. The survey collected participant information, including age and identified gender (Appendix G).

Qualitative

Qualitative data were collected using an open commentary box. The commentary boxes allowed the participants to answer the specifically structured questions the researcher developed; however, the participants' thoughts were not structured but explored. Commentary boxes should address specific topics assessed and gather data that cannot be predicted (Polit & Beck, 2021).

The commentary boxes included open-ended questions pre-approved by the thesis committee (Appendix A). They were positioned at the end of the GAMEX portion of data collection and were available to any student who voluntarily chose to write responses.

Data Analysis

Quantitative data analysis was completed using the Statistical Package for Social Science (SPSS) IBM SPSS® Statistics Version 29.0.0.0 (241). Both descriptive and inferential statistical analyses were used. Descriptive statistics, means, percentages, and standard deviation (SD) were used to report sociodemographic data, including sample characteristics, to evaluate differences across participant demographics and assess extreme scores and distribution (Polit, 2010). Inferential statistics identified relationships or differences between the GAMEX scores (Polit, 2010). The data collected from the GAMEX was ordinal level data indicating that non-

parametric testing was appropriate. One-sample Wilcoxon sign rank test was performed on each dimension within GAMEX. The point of comparison was four, suggesting that students neither agreed nor disagreed with each dimension, but were neutral. A level of significance of ($p < 0.05$) or ($p < 0.01$) was used to determine if there is a significant relationship or difference. Confidence intervals were calculated at a 95% level. Correlations were assessed between each dimension and the participant's age using Spearman's Rho. A Cronbach Alpha was calculated for each dimension, then each dimension was averaged to calculate the overall reliability index for GAMEX using this dataset A level of significance of ($p < 0.05$) or ($p < 0.01$) to determine if there is a significant relationship or difference.

With consent from the thesis committee, the *Activation Dimension* was removed from the analysis. This dimension did not have applicability to this research project. Increasing students' perception of being frenzied, jittery, or activated is not the primary concern of this project. Instead, assessing enjoyment and engagement were the primary areas of interest.

Qualitative data analysis began with pooling all responses to the questions. Coding took place to develop a coding scheme, identifying interesting, salient, and distilling the essential features relative to the investigation (Polit & Beck, 2021). Codes are generated based on the words and phrases the students will use in their open-ended responses (Polit & Beck, 2021). Using coding enhanced credibility and dependability because it utilized the participant's actual words, increasing the trustworthiness of the outcomes (Polit & Beck, 2021). The codes were connected using familiar themes and thematically analyzed. The themes and thematic analysis were independently reviewed by the thesis supervisor (JT). This enhanced confirmability as the independent review established congruence between the two independent reviews and maintained the authenticity of participants' voices (Polit & Beck, 2021).

Adding open-ended question allowed both the quantitative and qualitative data together, where the qualitative data described statistics-by-themes (Guetterman et al., 2015). The quantitative data was highlighted by the themes established through the qualitative analysis. These themes were used to explain the GAMEX data output, mainly if one dimension of GAMEX is notably higher than another.

Research Ethics

Ethics approval was obtained from the Research Ethics Board (REB) at the University of Ottawa before data collection (Appendix J). The primary researcher and all committee members completed the Tri-Council Policy Statement 2 (Appendix I). As noted above, informed consent was obtained from each participant.

Participant anonymity was maintained in all aspects of the research process. The participants remained anonymous. Collecting emails for the $25.00 Starbucks gift card was done in a completely separate survey resulting in no identifiers. All voluntary participants were able to review their written responses in their commentary boxes upon request.

This study posed a low risk to participants and no more risk than would be experienced in everyday life.

All data was stored on an encrypted file on a password-protected university computer. All of the data will only be accessible to the researcher. The data will be kept for five years after submitting the completed thesis for publication. During those five years, the data will be held in an encrypted password file on a password-protected University of Ottawa computer.

Completed Analysis

Quantitative data was obtained from participant demographic surveys, the GAMEX questionnaire and three accompanying open-ended questions. Data were analyzed through statistical analysis using the Statistical Package for Social Science (SPSS™ version 29) program.

Descriptive statistics were used to report the age and gender of the participants. Relative and absolute values were calculated for age and gender, including the mean, median and standard error. Median and standard deviation values, skewness and kurtosis, including their respective standard errors, were calculated for the GAMEX data. GAMEX questions were reported on a Likert scale indicating 1=strongly agree; 2=agree; 3=somewhat agree; 4=neither agree nor disagree; 5=somewhat disagree; 6=disagree; or 7=strongly disagree. Data was considered ordinal level, which supports non-parametric analysis. One-sample Wilcoxon signed-rank test was performed on each dimension (*enjoyment, absorption, creative thinking, absence of negative affect,* and *dominance*) within GAMEX. The point of comparison was four, indicating that students neither agreed nor disagreed with each dimension but were neutral. Confidence intervals were calculated at a 95% level. Spearman's Rho assessed correlations between each dimension and the participant's age. Finally, a Cronbach Alpha was calculated for each dimension, and then each dimension was used to calculate the overall reliability index for GAMEX using this dataset.

The statistical tests performed on this data best suit this specific dataset. The one-sample Wilcoxon signed-rank test is a nonparametric used with an ordinal-level dataset (Polit & Beck, 2021). Additionally, the one-sample Wilcoxon signed-rank test "involves taking the difference between paired scores and ranking the absolute difference" (Polit & Beck, 2021, p. 396). The data from this Likert scale is ordinal, and if the median value deviated from the neutral value, 4=neither disagree nor agree, supporting the use of this test. The confidence interval is useful

because it gives a range, in this case, a 95% likeliness, that the median value will fall within this range (Polit & Beck, 2021). This allows for an extension to the population parameter (Polit & Beck, 2021).

We also wanted to clarify if age correlated with how participants experienced VIPER. Spearman's rho is a nonparametric correlation index for ordinal-level data, where the values range from -1.00 to +1.00, -1.00 indicating a complete disassociation and +1.00 indicating a complete association (Polit & Beck, 2021).

Data for each dimension were merged to give a single value for analysis. This decreased the potential for Type 1 error, rejecting a null hypothesis when true because it decreased the volume of data being interpreted (Polit & Beck, 2021). It also allowed the average median value to be used within the one-sample Wilcoxon signed-rank test.

The student researcher gathered all qualitative responses under the heading of their respective question. Responses that shared similarities were clustered, and thematic analysis was completed. Thematic analysis identifies themes or patterns that share similar attributes (Maguire & Delahunt, 2017; Polit & Beck, 2021). The primary student researcher completed the thematic analysis. Thematic coding and clustering of semantic themes were performed. Sentences representing similar ideas were clustered into groups, and responses within these groups were further evaluated.

Quality Criteria

To strengthen the quality of this research study, the design, sampling plan, and data collection methods were considered. Quasi-experimental research is practical, a major strength of this study design, and beneficial to this study as we tested such a novel form of gamified simulation (Polit & Beck, 2021). Another advantage of this study design is that participants are

not randomized, making these types of studies more acceptable to a larger group, resulting in more generalizable outcomes (Polit & Beck, 2021). In this case, convenience sampling recruited all members of the target population who met the eligibility criteria and enhanced representativeness for external validity and transferability across populations (Polit & Beck, 2016). We calculated the minimum number of participants to using the University of California, Los Angeles G*Power calculation software to determine statistically significant results.

Collecting both quantitative and qualitative data is paramount to the success of this research and increases the inference quality (Polit & Beck, 2021). Inference quality reflects the internal validity and statistical conclusion validity of quantitative data and the credibility of qualitative data (Polit & Beck, 2016). Using the quantitative data from GAMEX, the results provide strong numerical conclusions tied to the validated and reliable dimensions of the tool (Eppmann et al., 2018). Eppman et al. (2018) noted that the GAMEX has acceptable internal consistency reliability as demonstrated by the high Cronbach Alpha and retains construct validity. Furthermore, the psychometric properties of the GAMEX were examined as they may affect internal validity.

The GAMEX data quantifies the gameful experience but does not elucidate why participants feel this way. The open-ended qualitative questions provide insight into why participants experienced VIPER in a particular way. This data collection is linked with the study intent and research question, further bolstering the inference quality. We ensured credibility in qualitative analysis by having prolonged engagement with the data and member checks. Confirmability is enhanced because direct participant quotes were used in the analysis and discussion, ensuring participants' viewpoints and interpretations are not invented by the investigator (Polit & Beck, 2021).

We further ensured quality criteria by testing the assumptions for the statistical tests. Importantly for the one-sample Wilcoxon signed-rank test, the dependent variable was ordinal level, but also the participants were randomly sampled within the inclusion criteria (Polit, 2010).

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Chapter 5 – Results

Quantitative Data

Descriptive Statistics

Initially, 55 participants completed the demographic survey, GAMEX, and three open-ended questions; however, 3 participants indicated in the online consent form that they did "not consent to participate in the study"; therefore, their data was removed. The total number of participants who consented to participate in the study was 52. All participants fully answered all questions from the GAMEX tool.

As seen in Table 1, 98.1% (n=51) participants identified as female and 1.9% (n=1) participant identified as male. No student identified as 'other.' The participants do not accurately represent Canadian nurses, where 91% are female and 9% are male (Canadian Institute for Health Information, 2022).

Participants ranged from 18 to over 30 years old (Table 2). The frequency of participants who were between twenty to 20 to 21 years old was 80.8% (42), participants aged 18 to 19 years old 3.8% (2), aged 22 to 23 years old 7.7% (4), aged 24 to 25 years old 1.9% (1), and greater than 30 was 5.8% (3) of total participants. The median age was 20 to 21 years (Table 3). The most significant age frequency was in the 20 to 21-year-old range. This allowed us to see if a specific age range experienced VIPER differently than others. The benefit of displaying the data as a frequency is that it allows the reader to view the distribution (Polit, 2010).

GAMEX Tool

Normality tests were run on each of the dimensions. The Kolmogorov–Smirnov test was used because the sample size exceeds 50 participants (Mishra et al., 2019). *Enjoyment* (p=0.2), *Creative Thinking* (p=0.2), and *Absence of Negative Effect* (p=0.17) were all statistically

insignificant, indicating they were normally distributed. *Absorption* (p=0.021) and *Dominance* (p=0.009) were statistically significant, failing the normality test and not being normally distributed. The Kolmogorov-Smirnov results are highlighted in Table 4.

Within each dimension, the related questions were averaged for each participant, providing an overall average score for the respective dimension. These average scores were used in the One-sample Wilcoxon sign rank test to calculate p-values and confidence intervals. The p-values correspond with the null hypothesis that each sample's medians will equal four. Four was used as the neutral middle, where results higher than four correspond with dislike in the dimension, and results lower than four correspond with liking in the dimension. A summary of the results is highlighted in Table 5. Reliability statistics were calculated for each dimension. Cronbach Alpha (Cronbach α) scores were used as the internal reliability index, and the overall average for GAMEX with this dataset is 0.79.

Enjoyment

As seen in Table 6, the z-statistic for *Enjoyment* was 2.666; the resultant median does not equate to four ($p<0.008$). The median score is 4.92 (CI 4.1585, 5.0466). The median score was above four, and the confidence interval did not cross four. The corresponding Cronbach α for *Enjoyment* was 0.954.

Absorption

As seen in Table 6, the z-statistic for *Absorption* was 4.064; the resultant median does not equate to four ($p<0.001$). The median score was 5.42 (CI 4.6258, 5.4895). The median score was above four, and the confidence interval did not cross four. The corresponding Cronbach α for *Absorption* was 0.924.

Creative Thinking

As seen in Table 6, the z-statistic for *Critical Thinking* was 1.803; the null hypothesis that the resultant median does equate to four was statistically significant (p=0.071), lending support to the median score being four. The median score was 4.38 (CI 4.0191, 4.904). The median score was above four, and the confidence interval did not cross four. The corresponding Cronbach α for *Creative Thinking* was 0.914.

Absence of Negative Affect

As seen in Table 6, the z-statistic for *Absence of Negative Affect* is -3.333; the resultant median does not equate to four (p<0.001). The median score was 3.00 (CI 2.7675, 3.6428). The median score was below four, and the confidence interval did not cross four. The corresponding Cronbach α for *Absence of Negative Affect* is 0.821.

Dominance

As seen in Table 6, the z-statistic for *Dominance* was 3.607; the resultant median does not equate to four (p<0.001). The median score was 4.33 (CI 4.3203, 4.9361). The median score was above four, and the confidence interval did not cross four. The corresponding Cronbach α for *Dominance* was 0.657.

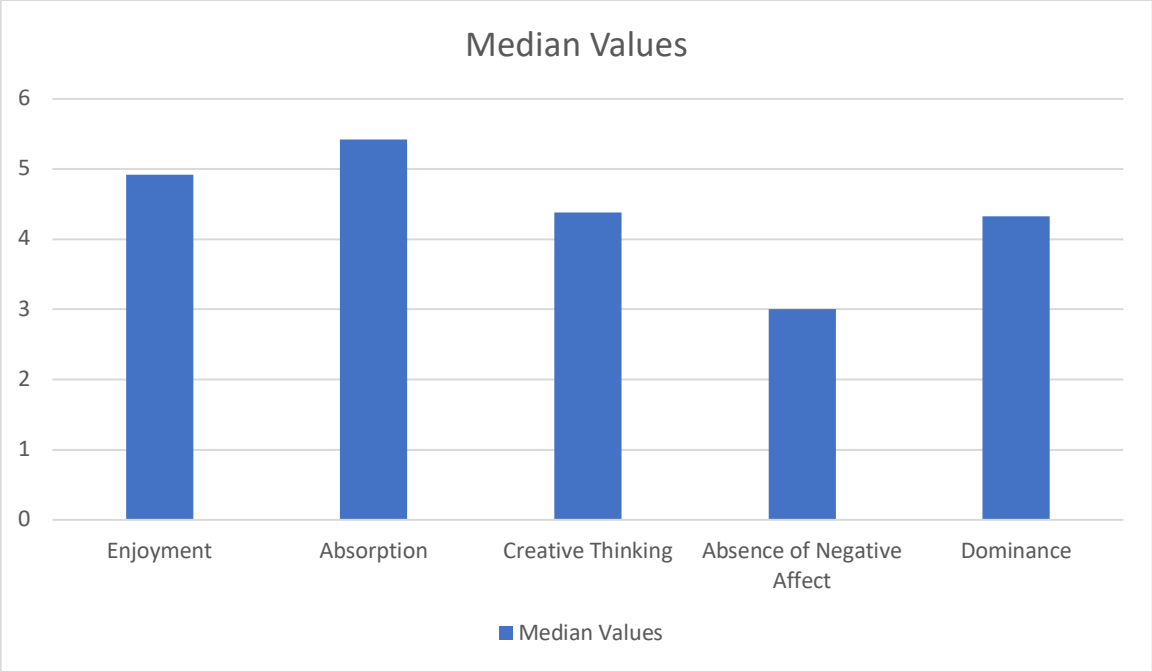

Figure 3: Median Values

Correlational Testing

Spearman's Rho was used to determine if there was any correlation between the age ranges and GAMEX subcategories. There was no missing data, and all participants were accounted for. All p-values were statistically insignificant, lending support that participant's age did not correlate with any of the subcategories, as seen in Table 7.

Qualitative Data Analysis

Participants responded to three open-ended short-answer questions at the end of the GAMEX questionnaire. All responses were collated verbatim. Responses varied in length – some were two-worded, while others were short paragraphs. The participants were not given a minimum or maximum number of words for their responses. The principal investigator completed a modified thematic analysis due to the limited responses to the study's qualitative questions. Sentences and paragraphs representing similar ideas were clustered into groups, and responses within these groups were further analyzed for common themes. Many participants

directly responded to the question impacting knowledge, skill or judgment, while many others gave an overall response to the question. All participant responses are highlighted in Appendix K.

Knowledge, Skill and Judgement

Of the 52 participants, 48 answered the question. Emergent themes included enhanced knowledge, skill or judgment.

Knowledge

In terms of knowledge, 18 reported improved knowledge. One participant stated, "I learned more information about blood transfusions in a practical setting." While 17 perceived the VIPER reinforced perceived knowledge acquisition. One participant stated VIPER "allowed me to apply the knowledge I have"

Skill

Participants reported it improved their skills (n=9)

> *The VIPER game increased my practical skills as it forced me to go from task to task without having the ability to move onto the next task before the previous one was complete. Moving from task to task it allowed me to go step to step in a real life simulation rather than just simply memorizing the steps in a textbook.*

or reinforced their skills (n=8)

> *This game helped solidify the process of transfusing blood. It was helpful that I could ask the other nurses around to know what to do next if I got stuck. I feel that I have a better understanding of the full process from taking the vitals, checking the order, administering the transfusion and then reassessing. It was also helpful as a refresher for the math required with medication.*

Clinical Judgement

Clinical judgment combines experiences, knowledge, critical thinking and reasoning that enables nurses to determine appropriate interventions (Klenke-Borgmann et al., 2020; Manetti, 2019; van Graan et al., 2016). Upon completion of the VIPER, 4 participants indicated perceived enhanced clinical judgement following gameplay. This was supported by one participant who states, “I felt that I used my judgment to decide what to do next like when I had to call the doctor because of the reaction…” While 5 perceived it reinforced clinical judgement. One participant stated, “it reassured me for what to do in real life should someone have some sort of reaction (rash)…” Contradictorily, (n=5) indicated the VIPER did not support or enhance their knowledge, skills or judgement. These participants experienced, most notably, that VIPER increased frustration. One participant stated, “…I got so frustrated playing the game cause the buttons were laggy and it would take several tries to even turn the screen around...”

Gameplay Experience

The second open-ended question asked, 'What suggestions do you have that would improve the gaming experience?' Related to gameplay experience, 49 participants responded identifying themes of buffering issues, navigational/directional cues and provided suggestions for improvement.

Buffering Issues

The most frequent responses involved technical issues. This included computer glitching and lagging (n=30),

> [The] *game was super slow. I got so frustrated playing the game cause the buttons were laggy and it would take several tries to even turn the screen around. Some of the nurses would talk to me and I never even clicked on them. I would have enjoyed it much more if*

the game didn't test my patience. But if this issue was fixed, I would 100% recommend to people.

Navigation/Directional Cues

Other technical issues involved navigation and/or directional cues (n=22). “Give more indicators where the person is to click and make it easier to "look around" a room.”

Suggestions for Improvement

As the VIPER was a text-based application to support accessibility issues, the inclusion of voice-based interaction was not applied. Participants suggested the addition of voice-based interactions would have been optimal. One participant stated, “[include] voice actors.”

To align with their clinical environment, participants suggested the addition of hand sanitizers outside the rooms to further replicate their current practice setting. “People should be washing hands when exiting the room. hand sanitizer outside the room/by bed would be more accurate to reality.” The VIPER only required hand washing at the sink inside the patient room before care could progress.

Overall VIPER experience

The final open-ended question addressed overall experience with the VIPER module asked, 'Is there anything else you would like to share about your VIPER experience?' (Appendix M). The final question had 41 responses highlighting enjoyment mediated certain level of frustration related to technology.

Enjoyment

Some participants (n=13) highlighted they enjoyed the experience. “I think it is an amazing idea and if it didn't glitch then I would have played it for fun even.” While 12 found the

experience frustrating. “You need to improve it, very frustrating. More time spent trying to work the system then actually learning how to give a blood transfusion”

Obtaining the open-ended responses provided context to the GAMEX data. It explains the findings for a thorough understanding of this assessment of such a novel educational modality.

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Table 1: Sociodemographic Data

Age	Frequency	Percent	Valid Percent	Cumulative Percent
18-19	2	3.8	3.8	3.8
20-21	42	80.8	80.8	84.6
22-23	4	7.7	7.7	92.3
24-25	1	1.9	1.9	94.2
30+	3	5.8	5.8	100.0
Total	52	100.0	100.0	
Gender				
Man	1	1.9	1.9	1.9
Woman	51	98.1	98.1	100.0
Total	52	100.0	100.0	

Table 2: Frequencies Statistics

		Identifying Gender	Age
N	Valid	52	52
	Missing	0	0
Mean		1.0192	3.3654
Median		1.0000	3.0000
Mode		1.00	3.00
Std. Deviation		.13868	1.23715
Skewness		7.211	3.197
Std. Error of Skewness		.330	.330
Kurtosis		52.000	9.993
Std. Error of Kurtosis		.650	.650
Range		1.00	6.00
Sum		53.00	175.00

Table 4: Tests of Normality

	Kolmogorov-Smirnov		
	Statistic	df	Sig.
Enjoyment	.100	52	.200
Absorption	.134	52	.021
Creative Thinking	.079	52	.200
Absence Of Negative Affect	.110	52	.170
Dominance	.144	52	.009

Table 5: Hypothesis Test Summary

	Null Hypothesis	Test	Sig	Decision
1	The median of Enjoyment equals 4.00.	One-Sample Wilcoxon Signed Rank Test	.008	Reject the null hypothesis.
2	The median of Absorption equals 4.00.	One-Sample Wilcoxon Signed Rank Test	<.001	Reject the null hypothesis.
3	The median of Creative Thinking equals 4.00.	One-Sample Wilcoxon Signed Rank Test	.071	Retain the null hypothesis.
4	The median of Absence Of Negative Affect equals 4.00.	One-Sample Wilcoxon Signed Rank Test	<.001	Reject the null hypothesis.
5	The median of Dominance equals 4.00.	One-Sample Wilcoxon Signed Rank Test	<.001	Reject the null hypothesis.

Table 6: One-Sample Wilcoxon Signed-Rank Test

			Statistic	Std. Error
Enjoyment	Median		4.9167	
	95% Confidence Interval for Mean	Lower Bound	4.1585	
		Upper Bound	5.0466	
	Std. Deviation		1.59491	
	Standardized Test Statistic		2.666	
	Skewness		-.409	.330
	Kurtosis		-.520	.650
Absorption	Median		5.4167	
	95% Confidence Interval for Mean	Lower Bound	4.6258	
		Upper Bound	5.4895	
	Std. Deviation		1.55119	
	Standardized Test Statistic		4064	
	Skewness		-.413	.330
	Kurtosis		-.978	.650
Creative_Thinking	Median		4.3750	
	95% Confidence Interval for Mean	Lower Bound	4.0191	
		Upper Bound	4.9040	
	Std. Deviation		1.58917	
	Standardized Test Statistic		1.803	
	Skewness		.073	.330
	Kurtosis		-.863	.650
Activation	Median		4.3333	
	95% Confidence Interval for Mean	Lower Bound	4.1775	
		Upper Bound	4.8866	
	Std. Deviation		1.27360	
	Standardized Test Statistic		2.719	
	Skewness		.255	.330
	Kurtosis		-.702	.650
Absence Of Negative Affect	Median		3.0000	
	95% Confidence Interval for Mean	Lower Bound	2.7675	

		Upper Bound	3.6428	
	Std. Deviation		1.57202	
	Standardized Test Statistic		-3.333	
	Skewness		.465	.330
	Kurtosis		-.584	.650
Dominance	Median		4.3333	
	95% Confidence Interval for Mean	Lower Bound	4.3203	
		Upper Bound	4.9361	
	Std. Deviation		1.10584	
	Standardized Test Statistic		3.607	
	Skewness		.256	.330
	Kurtosis		-.271	.650

Table 7: Spearman's Rho Correlations

		Age	Enjoyment	Absorption	Creative Thinking	Absence Of Negative	Dominance
Age	Correlation Coefficient	1.000	.133	.118	.041	-.029	.055
	Sig. (2-tailed)	.	.347	.406	.773	.839	.700
	N	52	52	52	52	52	52
Enjoyment	Correlation Coefficient	.133	1.000	.282*	.814**	-.604**	.277*
	Sig. (2-tailed)	.347	.	.043	<.001	<.001	.047
	N	52	52	52	52	52	52
Absorption	Correlation Coefficient	.118	.282*	1.000	.475**	-.125	.496**
	Sig. (2-tailed)	.406	.043	.	<.001	.377	<.001
	N	52	52	52	52	52	52
Creative Thinking	Correlation Coefficient	.041	.814**	.475**	1.000	-.474**	.522**
	Sig. (2-tailed)	.773	<.001	<.001	.	<.001	<.001
	N	52	52	52	52	52	52
Absence Of Negative	Correlation Coefficient	-.029	-.604**	-.125	-.474**	1.000	-.181
	Sig. (2-tailed)	.839	<.001	.377	<.001	.	.199
	N	52	52	52	52	52	52
Dominance	Correlation Coefficient	.055	.277*	.496**	.522**	-.181	1.000
	Sig. (2-tailed)	.700	.047	<.001	<.001	.199	.
	N	52	52	52	52	52	52

Chapter 7 - Discussion

Escape rooms are becoming increasingly popular in nursing education in recent years as a fun and engaging way to learn and apply knowledge in a variety of subjects. These interactive games involve solving puzzles and completing challenges to "escape" a room or scenario. The learning strategy is now being integrated into the virtual environment. This research study explored nursing students' gameful experience with the Virtual Interactive Puzzle Escape Room (VIPER), focusing on a complex clinical intervention, a blood transfusion.

To assess the gameful experience of the VIPER Blood Transfusion game, this research study utilized the GAMEX questionnaire and three open-ended short-answer quantitative questions. The GAMEX tool is a reliable and valid scale measuring users' gameful experience while engaging in education-based gameplay (Eppmann et al., 2018). GAMEX evaluates gameful experience through six dimensions; *enjoyment, Absorption, creative thinking, activation, absence of negative affect,* and *dominance*. GAMEX is designed for predominant use within digital gaming experiences (Eppmann et al., 2018). The questions prompted participants to further share their experience with this novel learning application strategy. We also evaluated whether there was any relationship between age and gameful experience.

Recent studies into escape room serious games have indicated positive experiences (Anguas-Gracia et al., 2021; Pozo-Sánchez et al., 2022; Tan et al., 2017). Most studies involved only in-person escape rooms and not virtual adaptations of escape rooms due to the innovative nature of virtual escape rooms used in education. Findings from a current literature review identified that the creation and evaluation of a virtual escape room, such as the one used in this study, was one of the first of its kind (Pozo-Sánchez et al., 2022). The VIPER intervention was

an integration of educational escape room pedagogy using gamification-based theories used in virtual simulation games.

Participants in this study indicated the concept of VIPERs was both innovative and exciting. Following exposure to the VIPER Blood Transfusion game, participants identified this learning strategy enhanced their knowledge, skills and judgement related to both medication calculation and the process involved in blood transfusions. Other researchers have previously reported the perceived enjoyment, improved efficacy, and knowledge gained in serious games and escape rooms (Backhouse & Malik, 2019; Korenoski et al., 2021; Lee, 2015; Stringfellow, 2021; Tan et al., 2022).

Enjoyment

Results from the GAMEX scores within this study related to the Enjoyment dimension of VIPER gameplay showed mixed results, with median scores leaning toward ambivalence regarding perceived enjoyment. The results are slightly skewed towards the negative, with the greatest frequency selecting the *'somewhat disagree*' response. This finding is contrary to findings by other researchers when they examined participant perceptions in either virtual simulations or escape rooms where participants showed high levels of enjoyment (Anguas-Gracia et al., 2021; Tan et al., 2017; Tan et al., 2022; Verkuyl et al., 2022). Although slightly less than half of the study participants identified a positive response for enjoyment in the GAMEX questionnaire, those who indicated less favourable enjoyment scores seemed to be related to technical issues. Many participants indicated they would have liked the game more if they were not struggling to manage the computer challenges. Challenges within the game may lead to more frustration than enjoyment (Bopp, 2006). This being the case, one could assume that those who had fewer technical issues had greater enjoyment. The high number of responses in

the qualitative section indicates that computer challenges were frequent, occurring to many but not all participants, lending support to explaining of technical issues resulting in impaired enjoyment of VIPER gameplay. When participants did not experience these technical issues enjoyment scores were significantly higher.

Researchers from Spain assessed a virtual and face-to-face escape room using a descriptive and correlational experimental design. Participants (n=105) were Spanish university students assessing two gamified experiences where game contents included levels of curricular concretion, elements of didactic programming and attention to diversity. Participants were assigned to either a face-to-face group or a virtual group. Once completed, both groups assessed the experience using GAMEX (Pozo-Sánchez et al., 2022). The researchers found that while both groups enjoyed the gameful experience, there was greater enjoyment in the face-to-face group. This result deviates from our results as there was clear enjoyment in the virtual game for Pozo-Sánchez et al., (2022).

Enjoyment is an integral component of motivation, often associated with learning and skill acquisition (Gopalan et al., 2017; Kaše et al., 2019; Tohidi & Jabbari, 2012). The distinction between virtual simulation and escape room must be made because VIPER amalgamates virtual and escape room while incorporating an interactive component. This is important as the VIPER game is one of the first virtual escape rooms evaluated as an educational knowledge application resource. Collecting gameful experience data is imperative for game-based improvements. Despite the slightly lower scores in the Enjoyment dimension of gameplay, the median value still fell within the neutral range. This suggests that resolution of computer technology issues indicated by participants, participants perceived enjoyment should improve.

Absorption

The *Absorption* dimension of the GAMEX toll involves game flow, presence in the game and the feeling of time passing, and immersion, which are components of engagement (Eppmann et al., 2018; López-Belmonte et al., 2020). Study participants indicated more neutral aspects of *Absorption* in the gameful experience. Participants further described in the open-ended questions that *Absorption* in the gameful experience was primarily hindered due to computer buffering issues. The delay in progression in gameplay, while the computer program buffered, was distracting to players.

There are various barriers that have been identified in the literature that may impede learners' *absorption* of gamified education modalities. Typically these involve unrealistic game fidelity (Deterding et al., 2011), poor game design (Kapp, 2012), lack of feedback (Klock et al., 2020), and overemphasis on competition (Sailer et al., 2017). These identified barriers were taken into consideration when developing the VIPER game. One of the key barriers to learner *absorption* in gamification is the use of unrealistic learning experiences, not representative of the real world. This results in learner disengagement and impaired motivation. For example, when a gamified educational platform uses points or badges as a reward system, the learner does not translate how these rewards reflect in real-world nursing practice. In that case, they may not see the value in participating in the game (Deterding et al., 2011). The choice of integrating key nursing skills of medication dose calculations and nursing responsibilities related to the administration of blood transfusions was based on identified priority challenges experienced by nursing students.

Poor game design was another common barrier to learner *absorption* described in the literature. This can include confusing or overly complicated game mechanics, unappealing

graphics, or unengaging storylines. If the game design is not appealing or engaging, learners may quickly lose interest and become disengaged from the learning experience (Hamari et al., 2016; Kapp, 2012). Although usability testing was performed on the VIPER games prior to study integration, specifics regarding computer operating functionality were not considered, as all participants during usability testing identified no buffering issues. Study participants open-ended question responses indicated they still perceived enhanced knowledge, skills and judgement after using VIPER despite the buffering game design challenge.

Feedback is essential to any effective learning experience, especially in gamification. Learners who receive regular and meaningful feedback on their progress may feel motivated to continue with gameplay (Klock et al., 2020). The design of the VIPER was based on solving puzzles that validated successful nursing processes and calculation skills. Feedback for all actions was provided, culminating in 'clues' to progress the player through the game.

The final listed barrier to player *absorption* is an overemphasis on competition. While competition can be a motivating factor for some learners, it can also create a barrier to *absorption* for others. If the gamification experience is too heavily focused on competition, some learners may feel discouraged if they are not performing as well as their peers (Sailer et al., 2017). Although in-person escape rooms traditionally involve team-based activities, this study required individual gameplay. Additionally, although a time option could have been integrated into the VIPER, this option was rejected by VIPER developers to maximize *absorption*.

Participant *absorption* challenges in virtual simulation have been identified in educational research (Georgiou & Kyza, 2021; Korenoski et al., 2021). Korenoski et al. (2021) emphasize immersion in a problem-solving game creates an environment that stimulates collaboration,

problem-solving, and critical thinking while maintaining a fun and enjoyable experience for the learner.

Absorption in a learning modality is an essential dimension for the learner as it influences learning outcomes, especially in the computer-based learning environment (Chiquet et al., 2023). Many participants expressed that VIPER enhanced their learning outcomes, improving their knowledge, skills and judgement. Through this VIPER demonstrates high potential as an educational modality; even though many participants reported on GAMEX, they were unable to become fully absorbed into the VIPER. This is important because rectifying the technical issues should make VIPER-based gamification an effective educational modality.

Creative Thinking

The *Creative Thinking* dimension measured the level of player imagination and exploration (Eppmann et al., 2018; López-Belmonte et al., 2020). *Creative thinking* reflects optimal results when evaluated for virtual gamification compared to face-to-face interaction (Pozo-Sánchez et al., 2022). Our findings contradicts this premise as participants were neutral toward experiencing *creative thinking*.

Pozo-Sánchez et al. (2022) furthered that virtual gamification allows more adaption of the player to develop imagination and exploration. Along with *absorption*, participants can use their imagination and immerse themselves in the virtual game. Results from the GAMEX tool in our study were collated concomitantly with the open-ended questions. The somewhat neutral *creative thinking* scores reflected by the GAMEX tool suggest that participants in this study were challenged by computer buffering issues when becoming engaged in *creative thinking* opportunities. Computer buffering issues would be distracting enough to frustrate the user,

interrupting the *creative thinking* process, especially if the user was required to restart the application activity.

Positive outcomes are associated with the ability and efficiency of using digital technologies (Heidari et al., 2021). Heidari et al. (2021), in their study of (n=308) Iranian university students, found a statistically significant relationship between digital learning and the ability to use digital technology. Extrapolating from this, the inability or challenges when using digital technology negatively impacts *creative thinking* experiences, as demonstrated in our findings.

Absence of Negative Affect

Absence of Negative Affect measured participants' negative emotions and frustrations towards the game (Eppmann et al., 2018; López-Belmonte et al., 2020; Pozo-Sánchez et al., 2022). This study's GAMEX findings are somewhat surprising, indicating that participants did not have highly negative emotions or feelings toward VIPER. While this is consistent with other research findings (Pozo-Sánchez et al., 2022), computer challenges indicate that our participants were frustrated.

Multiple participants reported frustration with using VIPER while simultaneously, GAMEX scores identified an *absence of negative affect*, which appears counterintuitive. This suggests that participants understood the computer glitches within VIPER as a design issue as a byproduct of creating an innovative educational modality. As such, this supports the utility of VIPER as an educational modality. As participants scored the VIPER low on the *absence of negative affect*, the game itself was valued by participants. This is a reliable finding because the GAMEX Cronbach α for the *Absence of Negative Affect* is very high.

Dominance

The *Dominance* dimension measured the participants' confidence and the feeling that they were in charge of the gaming experience (Eppmann et al., 2018; López-Belmonte et al., 2020). The participants indicated they were neutral towards this dimension. The open-ended questions provided further insight into their perceived confidence within the game. Some participants indicated they knew how to progress through this clinical experience, indicating confidence they could complete the tasks. Others suggested they did not feel in control of the VIPER because they experienced navigation issues due to computer buffering challenges. Perceiving control over one's environment affects goal achievement (Jang et al., 2016).

Our data shares similarities with the findings of others. Jang et al. (2016) concluded from their survey-based study of (n=242) participants from the general public. The study's purpose was to examine essential factors of user experience between human-computer interaction. The authors concluded that a functioning computer interaction partly develops satisfaction and positively impacts control within the system (Jang et al., 2016). The balance between these two mindsets may explain the neutrality toward the dominance dimension; participants were confident they could do a blood transfusion but did not feel in charge of the game due to glitches.

This study assessed whether a correlation existed between the dimensions and different participants' ages. The results indicated no difference in perception between the participant’s age and GAMEX. This contradicts the findings by Katonai et al. (2023), who assessed n=223 healthcare workers' experience, attitudes and knowledge toward using serious games in education. The authors found significant differences by age group regarding knowledge and attitudes toward serious games in education (Katonai et al., 2023). They suggested these differences in attitudes were due to generational attitudes towards gaming. The participants ages

ranged from 18 to 60 and older. Since our participants are significantly closer in age, their disparities in attitudes toward gaming would not be as significant. Further, participants who chose to provide responses could have self-selected to participate because they have higher opinions of serious gaming at baseline.

In their systematic review, Mousavinasab et al. (2020) reviewed teaching methods and the utilization of technologies in nursing education. The authors highlight that educators need to empower nurses' abilities to think critically and problem-solve. The authors concluded that integrating computers, mobiles and other forms of technology into traditional education will improve educational outcomes (Mousavinasab et al., 2020). VIPER directly addresses advancing nursing education as a novel, cutting-edge educational modality. Since VIPER is so novel, challenges occurred utilizing the system, which is not unique. Researchers Loke et al. (2012) experienced similar technology challenges in their educational design research, testing simulation on (n=120) pharmacy students. They discuss how slow simulation speeds due to slow internet affected their learning activity. To accommodate their software limitations, they needed to adjust their simulation (Loke et al., 2012). The system's ability to be playable positively impacts achievements and outcomes (Jang et al., 2016). This affected every dimension within GAMEX, and the participants clearly articulated this within the open-ended questions. Moizer et al. (2009) conducted interviews with (n=11) staff in the United Kingdom who were involved in teaching with simulation and games. One of the themes highlighted is the importance of addressing technological concerns (Moizer et al., 2009). They concluded that addressing these concerns by providing additional resources for participants can help address technology concerns. They describe providing tangible resources such as technological infrastructure, academic support services, and additional materials as beneficial (Moizer et al., 2009).

Flood and Higbie (2016) found in their quasi-experimental study that simulation-based learning in combination with classroom lectures may help bridge the gap between the classroom and clinical environments and help strengthen cognitive learning. This is particularly important as students' attitude toward online learning impacts their engagement and learning (Ferrer et al., 2022; Liaw et al., 2008). Technological challenges negatively impacted attitudes towards VIPER. Despite this, students still believed their knowledge, skills and judgement improved. This speaks to the very high quality of VIPER. The researcher needs to address, evaluate and rectify technical challenges then VIPER must be re-evaluated. This will make the assessment of VIPER clearer so the researchers can better evaluate the participant experience.

Limitations

This study utilized convenience sampling, allowing participants with strong opinions to assert themselves in the research and affect the outcomes (Polit & Beck, 2021). The researcher did not consider the timing of when the participants would be completing the GAMEX survey and open-ended questions. Participants were asked to complete the survey during a stressful and challenging part of their university term, specifically during midterm evaluations. Baseline cognitive stress levels were elevated, as anecdotally reported by several participants. Course workload, clinical rotation requirements and personal challenges may have contributed to the participants' high levels of frustration.

During the usability testing, the participants did not experience any challenges with computer lagging and glitching. As usability testing typically involves 6-10 participants, this appeared to be inadequate with selected usability testers working within gaming and academia. When including a significantly higher number of participants required for this study, consideration of computer operating systems specifications was not obtained. Participants

involved in the usability testing had higher-end computer operating systems to run specialized programs not required by many undergraduate nursing students enrolled in this study. Although it is worth noting that many students today have access to high-performance computers and software through their universities, either through on-campus computer labs or remote access to cloud-based computing resources, it should not be taken for granted. Furthermore, many operating systems today are designed to be user-friendly and accessible to many users. Students can often use the same operating systems, albeit with potentially lower specifications. This may explain the various challenges experienced by some participants in this study.

As reported by several participants, there were challenges in navigating the game. Before the game started, there was an optional tutorial where participants learned how to navigate within the game. The participants who had challenges navigating within the game may have skipped this optional tutorial. Making the tutorial mandatory may prevent navigation-related challenges in future games.

Implications for Nursing Education

Innovative gamification is utilizing creative and engaging game elements in educational contexts to enhance learning outcomes. In nursing education, innovative gamification can offer several benefits to nursing students, including increased engagement, motivation, and knowledge retention. One of the most significant benefits of innovative gamification in nursing education is increased student engagement. Nursing students often face heavy course loads and complex subject matter making it difficult to stay focused and motivated. They are additionally challenged to apply nursing knowledge in a repeatable, safe, and consistent manner. By incorporating innovative gamification elements such as virtual simulations, game-based quizzes, and role-playing scenarios, nursing students can engage with course material in a more interactive and

entertaining way. According to a study by Liu et al., (2021), nursing students who participated in a gamified learning experience reported higher levels of engagement and motivation than those who received traditional instruction.

Innovative gamification, such as team-based VIPER gameplay can also promote collaboration and teamwork among nursing students. Nursing is a team-oriented profession, and effective collaboration and communication skills are essential for providing high-quality patient care. By incorporating gamification elements that encourage collaboration and competition, nursing students can develop these critical skills in a fun and engaging way. A study by Alghamdi & Alzahrani (2019) found that nursing students who participated in a gamified team-based learning experience reported increased collaboration and communication skills.

Another benefit of innovative VIPER gamification in nursing education is improved knowledge retention. By incorporating elements such as repetition, feedback, and reinforcement, nursing students can learn through trial and error, receive instant feedback, and reinforce their knowledge. According to a study by Woolwine et al. (2019), nursing students who participated in a gamified learning experience had better knowledge retention than those who received traditional instruction.

Finally, innovative gamification can help nursing students develop critical thinking skills by presenting them with real-world scenarios and challenges that require creative problem-solving. By incorporating elements such as realistic clinical experiences within a virtual world, nursing students can apply their knowledge and skills practically and meaningfully.

With adjustments made to VIPER based on participant responses, VIPER has the potential to offer another tool for educators to employ. Escape rooms are already proving an effective educational tool for healthcare education (Backhouse & Malik, 2019; Garwood, 2020;

Gómez-Urquiza et al., 2019), as is virtual simulation (Luctkar-Flude et al., 2021). Correcting the glitches and computer functioning errors could result in better participant reception and increased enjoyment, *Absorption*, and activation with VIPER leading to high *creative thinking* and feeling dominant within the game.

Implications for Future Nursing Research

There is a need for research on the effectiveness of virtual escape rooms in nursing and healthcare education. While this study is one of the first exploring VIPERS in nursing education, despite the issues with computer processing issues, this study has shown someone positive results and interest from nursing students to further engage in this form of gamification. As a result of this study, the VIPER developers have created a simple solution to mitigate the computer technology challenges experienced by some participants in this study. Further replication of this study with the required revisions is needed to accurately evaluate the value of VIPER gamification.

Additionally, there is a need for more rigorous research studies that can provide more conclusive evidence of the effectiveness of virtual escape rooms. Further studies are needed that compare the learning outcomes of students who participated in a virtual escape room activity to those who did not can help to establish the effectiveness of escape rooms in nursing education.

There is a need for research on the design and implementation of virtual escape rooms in nursing and healthcare education. Escape rooms can be designed in many different ways, and the effectiveness of a virtual escape room activity can depend on the quality of its design. Research studies that investigate the best practices for designing and implementing virtual escape rooms in nursing education can help educators create effective virtual escape room activities that achieve the desired learning outcomes. This should include individual versus team-based gameplay.

There is a need for research on the long-term impact of virtual escape rooms in nursing education. While many studies have focused on the immediate effects of escape room activities, there is a need to investigate whether the skills and knowledge gained from an escape room activity are retained over time and how they translate into clinical practice. Longitudinal studies that follow nursing students over several months or years can help to establish the long-term impact of virtual escape rooms in nursing education.

Furthermore, there is a need for research on the scalability and sustainability of virtual escape rooms in nursing education. While virtual rooms can be effective in small-group settings, it is unclear whether they can be scaled up to larger class sizes or implemented over an entire nursing program. Research studies investigating the scalability and sustainability of escape rooms in nursing education can help establish the feasibility of using virtual escape rooms on a larger scale.

In conclusion, while virtual escape rooms show promise as a gamification technique in nursing education, much research still needs to be done to understand their potential fully. Future research studies should focus on the effectiveness, design and implementation, long-term impact, scalability, and sustainability of virtual escape rooms in nursing education.

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Chapter 8 - Conclusion

In conclusion, innovative VIPER gamification has the potential to significantly benefit nursing education by increasing student engagement, promoting teamwork, improving knowledge retention, and developing critical thinking skills. By incorporating creative and engaging game elements into nursing education, educators can enhance the learning experience of nursing students and prepare them to provide high-quality patient care. However, further research is needed to fully understand the potential of innovative VIPER gamification in nursing education.

Appendix A: Questionnaire Guide

Questionnaire Guide

1. How did playing the VIPER game impact your knowledge, skill and judgement?
2. What suggestions do you have that would improve the gaming experience?
3. Is there anything else you would you like to share about your VIPER experience?

Appendix B: Literature Search Strategy

Search 1

Database:
Ovid MEDLINE(R) ALL <2007 to March 14, 2022>

#	Query	Results from 15 Mar 2022
1	(nurse or nurs or nursing or RN or medicine or medical or medic).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	3,106,497
2	(learn or learning or education or educate or teach or teaching).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	1,514,942
3	(game or gamification or serious game).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	32,248
4	(virtual or digital or simulation or sim).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	665,663
5	(Puzzle or escape or escape room).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	67,464
6	(effectiveness or effect or effective).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	5,280,873
7	1 and 2 and 3 and 4 and 5 and 6	5

Search 2

Database:
Ovid MEDLINE(R) ALL <2007 to March 22, 2022>

#	Query	Results from 24 Mar 2022
1	(serious game or game or gamification or games or playing or play or gameful or gaming).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism	838,770

	supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	
2	(learn or learning).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	524,811
3	(education or educate or knowledge or know).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	1,823,413
4	(develop or development or developing or create or build).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	4,124,505
5	(simulation or sim or fidelity).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	478,946
6	(nurse or nursing or student or medicine or medical or pharmacy or pharmacology).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	6,434,963
7	(clinical or clinic or training).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	5,249,808
8	(escape or escape room or room or leave or exit).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	328,710
9	1 and 2 and 3 and 4 and 5 and 6 and 7 and 8	13

Search 3

Database:
Ovid MEDLINE(R) ALL <2007 to March 22, 2022>

#	**Query**	**Results from 24 Mar 2022**
1	(serious game or game or gamification or games or playing or play or gameful or gaming).mp. [mp=title, abstract, original title, name of substance word, subject	838,770

	heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	
2	(learn or learning).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	524,811
3	(education or educate or knowledge or know).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	1,823,413
4	(develop or development or developing or create or build).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	4,124,505
5	(simulation or sim or fidelity).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	478,946
6	(nurse or nursing or student or medicine or medical or pharmacy or pharmacology).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	6,434,963
7	(clinical or clinic or training).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	5,249,808
8	(escape or escape room).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	58,744
9	1 and 2 and 3 and 4 and 5 and 6 and 7 and 8	6

Appendix C: Letter of Information

Letter of Information

Title of the Study: Virtual Interactive Puzzle Escape Room on Blood Transfusions

Sylas Coletto, RN
University of Ottawa, School of Nursing

Dr. Jane Tyerman RN, PhD, CCSNE, Supervisor
Assistant Professor, University of Ottawa

Incorporating games into education is a way to help students learn while supporting a fun and engaging environment! This research is designed to test the effectiveness of a novel education format called Virtual Interactive Puzzle Escape Rooms (VIPER). VIPER is a new way to help you learn material that combines simulation-based learning with a fun and interactive approach to learning. You will learn how to safely administer a blood transfusion to a patient while completing it in a safe and fun environment. Completed on a computer, you will tackle a series of problems within the simulation that, once completed, will unlock the next level of the simulation. After all problems are solved, the virtual patient will have received their blood transfusion.

You will be asked to complete an online questionnaire about your experience using VIPER. We will also ask you to answer three open-ended questions so we, the researchers, can learn how to improve future game design. You are not obligated to participate at any stage and are able to walk away at any point. Not participating will not affect any aspect of your education and will not affect your grades. We estimate completing the questionnaire and three open-ended questions to take approximately 30 minutes.

Please do not hesitate to email Sylas Coletto, should you have any questions about the research.

Thank you for your consideration,

The research team.

Appendix D: Consent Form

Consent Form

Title of the Study: Virtual Interactive Puzzle Escape Room on Blood Transfusions

Sylas Coletto, RN
University of Ottawa, School of Nursing

Dr. Jane Tyerman RN, PhD, CCSNE, Supervisor
Assistant Professor, University of Ottawa

Invitation to Participate: I am invited to participate in the abovementioned research study conducted by Sylas Coletto RN, in the context of a Master's thesis, under the supervision of Dr. Jane Tyerman.

Purpose of the Study: The purpose of the study is to determine if a Virtual Interactive Puzzle Escape Room based on Blood Transfusions are useful in teaching students the fundamentals of blood transfusions, medication calculations. Additionally, to understand how to improve the design and implementation of Virtual Interactive Puzzle Escape Rooms.

Participation: My participation will consist of a one-time participation in a Virtual Interactive Puzzle Escape Room that is completed on a computer. After completing the game, I will be asked to complete an online questionnaire and three open-ended questions so the researchers can learn about your experience completing the game. The topics that will be covered during the questionnaire surround enjoyment, and feelings during the game.

Risks: My participation in this study will entail that I volunteer information on my experiences during the Virtual Interactive Puzzle Escape Room. This may cause me to feel anxiety surrounding the completing a new form of learning, and being asked questions about my personal experiences. I have received assurance from the researchers that every effort will be made to minimize these risks, such as options to withdraw, creating pseudonyms for my name, options to refuse to answer any questions, and how there is no penalty to not/stop participating.

Benefits: My participation in this study will benefit future students and patient outcomes because it will help develop a new way of teaching and learning. By improving teaching modalities, students can become more engaged with material and learn it better, which benefits future patients because students are more prepared upon graduation.

Confidentiality and Privacy: I have received assurance from the researchers that the information I will share will remain strictly confidential. I understand that the contents will be used only for assessing the effectiveness of Virtual Interactive Puzzle Escape Rooms and that my identity will be protected, and anonymity will be guaranteed. In order to minimize the risk of security breaches and to help ensure my confidentiality, it is recommended that I use standard safety measures, such as signing out of my account, closing my browser, and locking my device when I am no longer using it/when I have completed the study.'

Conservation of Data: The data collected, such as questionnaires, consent forms, and data will be kept in a secure manner and will only be accessible by the researcher, researcher's supervisor, and the researchers thesis committee. The data will be kept for a 5-year period after the submission of the completed document. During that 5-year period, the data will continue to be kept in a password-encrypted file on a password-encrypted computer.

Compensation: If I choose to participate in the GAMEX questionnaire and three open-ended questions I will receive a $25.00 Starbuck gift card, through e-mail.

Voluntary Participation: I am under no obligation to participate and if I choose to participate, I can withdraw from the study at any time and/or refuse to answer any questions, without suffering any negative consequences. The choice to participate will have no impact on student's grades or relationship with the course professor. The student-researcher has no influence on my education, and is not in any position to influence my course professors in any way. If I choose to withdraw, all data gathered until the time of withdrawal will be removed from the dataset and not used in the study.

If I have any questions about the study, I may contact the researcher or their supervisor. If I have any questions regarding the ethical conduct of this study, I may contact the Office of Research Ethics and Integrity via email (ethics@uottawa.ca) or telephone (613-562-5387).

It is recommended that I keep/save/print a copy of this consent form for my records.

Acceptance: By selecting the consent statement below, I agree to participate in this research study.

- o Yes, I want to participate.
- o No, I do not want to participate.

Appendix E: GAMEX Tool

GAMEX Tool – Questions for participants

Enjoyment
Playing the game was fun.
I liked playing the game.
I enjoyed playing the game very much.
My game experience was pleasurable.
I think playing the game is very entertaining.
I would play this game for its own sake, not only when being asked to.

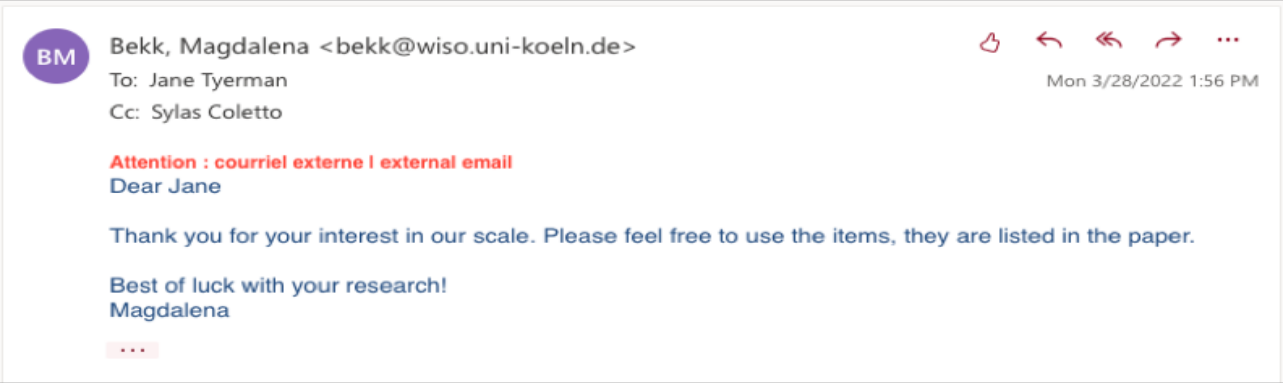
Absorption
Playing the game made me forget where I am.
I forgot about my immediate surroundings while I played the game.
After playing the game, I felt like coming back to the "real world" after a journey.
Playing the game "got me away from it all."
While playing the game I was completely oblivious to everything around me.
While playing the game I lost track of time.

Creative thinking
Playing the game sparked my imagination.
While playing the game I felt creative.
While playing the game I felt that I could explore things.
While playing the game I felt adventurous.

Absence of negative affect
While playing the game I felt upset.
While playing the game I felt hostile.
While playing the game I felt frustrated.

Dominance
While playing the game I felt dominant.
While playing the game I felt influential.
While playing the game I felt autonomous.

Appendix F: GAMEX Confirmation



Appendix G: Sociodemographic Information

Gender

- Woman
- Man
- Non-Binary/Non-Conforming
- Transgender
- Prefer Not to Respond
- Not Listed

Age

- 18-19
- 20-21
- 22-23
- 24-25
- 26-27
- 28-29
- 30+

Appendix H: Poster

Do you like having fun and playing games? You might want to join the

Virtual Interactive Puzzle Escape Room!

You're working in the hospital on a new medical ward. You have a patient who needs a blood transfusion.

Your VIPER Challenge? You will tackle a series of problems on a computer simulation that, once completed, will unlock the next level of the simulation - all while learning steps involved in giving blood transfusions. After all problems are solved, the virtual patient will have successfully received their blood transfusion - thanks to you!

You will be asked to complete an online questionnaire about your experience using VIPER. We will also ask to interview you so that we, the researchers, can learn how to improve future game-based learning innovations. You are not obligated to participate at any stage, and you are able to walk away at any time. Not participating will NOT affect any aspect of your education and will NOT affect your grades.

Interested? Of course you are! Please email Sylas Coletto at

Appendix I: TCPS 2 Certificate

PANEL ON
RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE 2022

Certificate of Completion

This document certifies that

Sylas Coletto

successfully completed the Course on Research Ethics based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2: CORE 2022)

Certificate # 0000800243

15 April, 2022

Appendix J: Certificate of Ethics Approval

31/08/2022

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE I CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number	H-08-22-8350
Titre du projet / Project Title	Perceived Effectiveness of Virtual Interactive Puzzle Escape Rooms for Upper Year Undergraduate Nursing Students
Type de projet / Project Type	Thèse de maîtrise / Master's thesis
Statut du projet / Project Status	Approuvé / Approved
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	31/08/2022
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	30/08/2023

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Sylas COLETTO	École des sciences infirmières / School of Nursing	Chercheur Principal / Principal Investigator
Jane TYERMAN	École des sciences infirmières / School of Nursing	Superviseur / Supervisor

Conditions spéciales ou commentaires / Special conditions or comments

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www.recherche.uottawa.ca/deontologie / www.recherche.uottawa.ca/ethics

Appendix K: Open-Ended Question 1

Q: How did playing the VIPER game impact your knowledge, skill and judgement?

Responses 48 Skipped 4

Helped understand the importance of Checking for Errors

Reinforced information learnt in lectures and modules

Improves knowledge, skill and judgement. It also helps enhance clinical-based knowledge

It improved my knowledge, skill and judgment by working through the puzzle and problem-solving.

I think I am more skillful in navigating a nursing scenario in real life since it really felt like I was in a hospital (went through the steps of using computer, talking to other staff, gathering meds, supplies, etc) I am also more knowledgeable in blood administration and the double checks required to safely administer blood products

It helped emphasize on the importance of rechecking and med rights, and understanding how easy it easy to make a mistake that can be highly influential

I learned more information about blood transfusions in a practical setting

Motivates me

It didn't to be honest. The things I wanted to know were how to set the blood up for transfusion, like priming the lines, but this is the only part we didn't do in the simulation

Practice medication calculation and medication administration through proper equipment collection and med checks.

The game increased my knowledge, skill and judgment. I was allowed to mess up and try again, as well as take my time to figure things out.

I learned more about blood tranfusion and blood typing.

It gave me additional information about medication administration

helpful in that it feels like I have some experience giving a blood transfusion now and I would feel more confident doing one in real life.

I get to have a real experience of being a nurse

I know more about blood transfusions

It made me incredibly frustrated and angry that a game that shouldn't take that long took me a couple of days due to how it was programmed. A case study would have been better.

I didn't know much about a nurse's role in caring for a patient receiving a blood transfusion before the game. I now feel that I at least know a little bit more.

It was helpful to figure out which supplies I needed for the blood infusion and med infusion. It reassured me for what to do in real life should someone have some sort of reaction (rash)because I probably would have stopped the infusion not called the doctor. Now I know to call the doctor instead.

It helped me think of the steps I would have to take before beginning the transfusion as well as showing me there are others on the floor to depend on if help was needed.

This game helped solidify the process of transfusing blood. It was helpful that I could ask the other nurses around to know what to do next if I got stuck. I feel that I have a better understanding of the full process from taking the vitals, checking the order, administering the transfusion and then reassessing. It was also helpful as a refresher for the math required with medication. I felt that I used my judgment to decide what to do next like when I had to call the doctor because of the reaction however, I was unsure why I didn't just stop the transfusion right away - we learned in the previous lecture that if there was any reaction you should immediately stop the transfusion. It makes sense to me that we didn't because the patient's vitals were stable and it was just the rash, but because it was explicitly said in the last lecture to stop if there was any reaction, I was confused.

it was good practice. more fun than just flash cards

Consolidated learning from class

I learned about blood transfusions and transfusion reactions.

Better understanding of shift workflow and necessary materials to compete a transfusion.

Having to repeat a lot of the tasks numerous times as a result of the VS glitching really drilled certain pieces of the patients' info into my head.

Very difficult to actually play, so I felt there was no large impact on my knowledge/skill since Ihad to skip ahead at many points due to game freezing/not working properly.

The VIPER game made me use some of my real world knowledge in knowing what i need to perform a blood transfusion and med administration for a patient

Reminded me of tasks relevant during that nursing intervention

It helped me practice my calculation skills and increased my knowledge on blood transfusions

It made me think about the steps needed to do a blood transfusion and it also helped me identify my areas of weakness knowledge-wise. It also helped me confirm that some of my knowledge and skills were sufficient for this game.

Helped me know how to do the process. Reminded me of important things to do.

I feel that it helped me to go through the motions of how this process occurs

Taught me the proper procedure to take when dealing with blood transfusion and knowing allthe symptoms

I dont really think it impacted my learning in any way

It was too distractingly frustrating to feel like I learnt anything

I liked finding the products and seeing what they actually look like in hospital setting.

I felt like it was similar to clinical

It got me to think critically about medication administration

It was so glitchy that I was more focused on just trying to get it to run and load than any of the knowledge I was supposed to be gaining.

it helped to go through the steps of a blood transfusion, what to look for and it was a good wayto understand the steps without actually doing it in a clinical setting

It improved my knowledge regarding tubing selections for transfusions.

I found it really cool to apply the math from my med surg labs to more "real world" typescenarios. I think practicing this was useful. Also reviewing the information that you give to the patient about adverse effects was useful.

I saw how important it was to be organized and collect all of the information needed before jumping into the activity.

Playing the VIPER game made me think about the next steps and made me think about all the information that I needed to collect before administering the intervention to my patient

It helps learn the new material better than just reading tons words.

allowed me to apply the knowledge i have

The VIPER game increased my practical skills as it forced me to go from task to task without having the ability to move onto the next task before the previous one was complete. Moving from task to task it allowed me to go step to step in a real life simulation rather than just simply memorizing the steps in a textbook.

Appendix L: Open-Ended Question 2

Q: What suggestions do you have that would improve the gaming experience?

Responded 49 Skipped 3

make it less laggy and more straightforward

Navigation was difficult; browser crashed a few times (need to optimize the program)

The game was glitchy and would often bring me back to a conversation I already had with a nurse, for example.

I think at some points I was unsure what I was supposed to do. It would be helpful to have more guidance

Making it less laggy. Having more directions maybe even having multiple choice options for us to pick from so its easier to understand instead of spending so much time figuring out what is a button and what is not.

Making sure that all information needed to succeed is in the game. For example the blood type was not included so I could not answer that portion of the module.

The system was super laggy and glitchy. I couldnt even move on to the next question without skipping through at the bottom

try to make easy accecible game. Is hard to drag.

It was so glitchy. This simulation took me 1.5 hours because it was so glitchy. Also at one point I kept clicking on the computers and would get a message from the male nurse that said "You can click on any of the computers", but it would tell me the same message every time I clicked a computer which was incredibly annoying. I was being told to click a computer, so I would click a computer and then the male nurse would say "click any computer". Multiple times something on the simulation would freeze and it would send me backwards a few steps, so I kept having to repeat things. I would suggest not giving this simulation to students in future years because it caused way more frustration than anything else.

Give more indicators where the person is to click and make it easier to "look around" a room.

Give hints to help get through the simulation when it's hard to figure out what to do

Slow wifi connection made the game difficult to play

Improve the voice acting

Game was supppppperrrr slow. I got so frusterated playing the game cause the buttons were laggy and it would take several tries to even turn the screen around. Some of the nurse would talk to me and I never even clicked on them. I would have enjoyed it much more if the game didn't test my patience. But if this issue was fixed, I would 100% recommend to people.

I think there are a lot of bugs in this game which make it very laggy

It was hard to complete because of glitches.

The game has some major flaws and is very glitchy. It kicked me out and restarted multiple times. The game takes up way too much memory when trying to play on a laptop. They're information missing, i.e. lab results for the blood type, consent forms.

The game was really slow to load at times. I tried using different browsers and different internet connections but ended up having to refresh the page almost continuously. Improving the run/load time would be super helpful.

Please make the blood type available or more obvious. I couldn't find it anywhere and had to guess. Please be clear about what the informed consent is, I saw in the chart that it was completed but I thought we had to collect a paper of some sort.

The game at times kept freezing and I had to restart about 7 times to be able to finish the game.

I had some difficulty with changing my orientation and it kept clicking on the nurse who would tell me to check the computer. Also, the nurse told me that any computer would work, but the one beside the clerk (with the headset) did not work. I would also check the puzzle that lets you into the med room because it would tell me I was wrong when I was certain about my answers and then after a few tries it would let me in even though I hadn't changed my answer. A similar thing happened with the med cart where I typed the name of the medication in and it wouldn't work even though I triple-checked the spelling. One other thing I would change was in the tutorial, some of the pop up boxes blocked each other - specifically the one right outside the patients room and the COW.

people should be washing hands when exiting the room. hand sanitizer outside the room/by bed would be more accurate to reality. movement was frustrating, remind players to have a paper for notes,

Game was glitchy, barely ran on my laptop

Split each stage into a separate sim. The sim was glitchy and I was kicked out a bunch of times, meaning I had to restart the sim >5 times.

Improve experience for people using a track pad. Maybe add buttons to navigate the halls instead of the mouse. I often got frustrated with the navigation.

Try to make maneuvering around the screens a bit smoother as it was lagging and often would not load the next screen after clicking certain things (eg: leaving the med room) and I would have no choice but to refresh the page and start over again which was very very frustrating

Make game run more smoothly, add a hint feature so student can move forward if stuck.

I was not able to located the blood type for my patient anywhere so I had to guess. I also got frustrated with the setup of the symptom selection for a reaction, especially since common symptoms I am familiar with were not options

System is very laggy and took away from the experience -Not clear where/how the blood group and Rh group should be written out -Very sensitive to spaces, even writing it after the pt name allows you not to go through

Easier to click around

Some instructions could be more clear (for example chart matching blood recipient & donor was confusing) and navigation could be made easier (it was a bit glitchy)

There were a lot of issues with the game not loading well, some glitches, a lot of needing to re-click some objects/choices, etc. Next time, instead of having us go back to the nursing station each time, it would be nice to also have a hint button and/or an answer key that shows the steps to answer some questions after a few failed attempts (Ex: How to solve the medication calculations, etc.). Also, it was quite annoying when the nurses kept saying I could click any computer in the nursing station and on the floor, but only one would work in the nursing station. Additionally, it was also annoying that I could not leave the nursing station after I completed the tasks, but instead I had to go back and click on each nurse just for them to say "Good job today" or "You are now ready to go do the transfusion". That makes it much more tedious and slow.

Lags a lot. Maybe give better hints, especially for calculation questions.

Seems slightly bugged, some of the information needed was never provided

Less time having to move around from station to station.

I truly dont know

Making it less buggy, it kicked me out half way and I had to restart, I also wasnt able to click many things

I found that the game would not proceed once I clicked the right materials. I felt like I did not know what to do. Maybe implement when you do a step it brings you to another step since I was confused.

Update it. It is very glitchy. As well, I could not find the blood type. I searched everywhere I could and eventually just guessed until I got it which really frustrated me

I could not find the patient's blood type in the chart.

It needs better software or something. The idea behind it is really cool but regardless of me having a fully functional laptop and good wifi, it took so long to run and was very glitchy, as I find with most of the vsims. However this one worked less well as we had to move around too. If it worked and there were readily available hints I feel like I would be able to work my way through and learn something.

i found that some things were missing (pts blood type) or things were just too hard to find

It felt very difficult to maneuver regarding the locations, turning around to find places was not easy. It was also slightly choppy and glitched a couple times.

When doing the blood type for the blood transfusion check, I got stuck and couldn't find the value on the chart and ended up having to guess. I'm not sure if I just missed it or if it wasn't there, but making it a bit more obvious might be good.

It was very laggy on my end, but it might have been a networking issue.

The gaming experience was pleasurable but unfortunately while playing it it was very glitchy and caused my computer to heat up so I'm not sure if it was my computer or the programitself.

I don't know this is just me or what, when I take all equipment of PRBC back to nursing station, I am not allowed to use the computer to recheck the chart before I answered the question for transfusion.

I'm not sure if this was a problem on my end but it wasn't allowing me to see everything including some of the pop up bubbles with info on them

I felt as though at times the game would take a while to load, when answering questions the game would freeze and take a minute to allow me to move on, I am not entirely sure if this was just the game, my wifi is not the best at times and that may have been the reason for the extended loading period.

Appendix M: Open-Ended Question 3

Q: Is there anything else you would like to share about your VIPER experience?

Responded 41, Skipped 11

Nothing

Good concept!

It was frustrating due to the glitches.

I really enjoyed having an alternate method of learning that is more like what a real life experience would be like

It was stressful and sometimes felt like theres too many options and instructions are too vague to direct us through the objectives.

I did not find it overly enjoyable and was frustrated that information seemed to be hard to findor missing completely.

You need to improve it, very frustrating. More time spent trying to work the system then actually learning how to give a blood transfusion

Ejoyed

I appreciate the idea behind the simulation/game, but it wasn't very successful to be honest

I found it hard to look around the room only could I move the view by moving the floor.

I enjoyed the game but found the software/wifi connection to be an obstacle while playing.

no

same as question 30

The glitches made the game frustrating however if this were to be improved I would have enjoyed the game much more.

Nope!

no

I think it is an amazing idea and if it didn't glitch then I would have played it for fun even.

I found this game helpful in solidifying the information I just learned in the lecture however, I was frustrated when certain things weren't working. Overall, it was helpful, there were just a few bugs.

sometimes the pt was not in the bed and there was no sink. game completely stopped responding once

no

It is not practical.

Overall enjoyed a different form of learning

Very laggy/difficult to navigate. I would hit the computer and it would automatically choose the nurse for me, even though I was trying to get information. In addition, there was no possible way to get the pt's blood type, as it was on his wrist band but each time I clicked the pt, he just said a nurse was waiting for me. Overall frustrating to navigate and I feel as if I did not learn much if anything.

Not all the computers worked and label the doors.

overall I liked it

Thank you for all the hard work and effort put into this game experience. The idea behind it is wonderful, but the quality should be improved. I have seen many other games/sims/"escape rooms" for healthcare students where it has a similar concept, but instead provided options to click on answers which then played a video to show the outcome (good/bad based on correct/incorrect choices). This seemed to be more engaging and more interesting, as well as had a better flow.

It was interesting

It was interesting, definitely a good take on learning in a new way

N/A

I got kicked out half way through and had to restart - not due to wifi

No

No

The software crashed multiple times and I had to start from the beginning repeatedly.

it was overall an okay experience

No!

I felt frustrated because I was trying to figure out the blood transfusion steps and while I was doing that someone was asking to verify a medication for them. It was quite realistic.

N/A

No

No

Overall, I enjoyed my experience with VIPER. It was informative and allowed me to use practical skills at home.

No