Increasing STEM Career Interest in Middle Schoolers Through a Health-Themed Serious Game

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Abstract: The U.S. continues to face a shortage of students entering Science, Technology, Engineering, and Mathematics (STEM) careers, including healthcare professions. Developing and strengthening a pipeline of programs, starting as early as middle school, to engage students in STEM and explore future STEM careers leading into higher education is a critical need. Game-based learning (GBL) offers a promising approach to spark interest in STEM fields, especially when classroom access to careers or real-world contexts is limited. One solution is the use of a well-designed, online, scalable serious game that empowers students to explore different health science careers otherwise inaccessible to typical middle schoolers. This study examines the educational impact of *End of Imperial*, a serious online medical mystery game that allows students to roleplay as police detectives solving a fatal crash while collaborating with science and healthcare professionals. During gameplay, students identify clues and solve challenges across multiple settings, from the crash site to the hospital and beyond. Middle school students from three distinct school environments—urban public, urban charter, and suburban public—played the game and completed a post-survey capturing changes in STEM career interest and health-related behaviours. Data collection used a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) to measure impressions immediately after gameplay. "Interest" was a measure of interest in health and science careers; "learning" measured self-perceived learning gains. Results across all locations showed a significant increase in health and science career interest. Students not only enjoyed the game but also reported substantial learning gains and increased confidence in science. In addition, students' awareness of healthy sleep habits, a key theme in the mystery, was increased. The game's community-based character representation, realistic narrative, and immersive roleplay contributed to engagement and learning. Findings suggest that serious games can positively influence middle school learners' attitudes toward STEM careers and personal health decisions when designed with authenticity and social relevance in mind. Overall, results indicated that the interactive game was well-received, playable across diverse communities, and strongly increased students' interest in STEM careers.

Keywords: STEM career exploration, Game-Based learning in education, Serious games for middle school, Health science education, Student engagement in STEM, Online educational games, Learning games, Sleep, Health, Health careers, 21st century skills, Critical thinking

1. Introduction

The United States faces a persistent shortage of students pursuing careers in science, technology, engineering, and mathematics (STEM), particularly in health science professions.

Limited early exposure to careers, uneven access to qualified science educators (U.S. Department of Education, 2015), and declining persistence among students who initially select STEM majors (Chen & Soldner, 2013; Wu & Uttal, 2020) contribute to this STEM career shortage. Middle school represents a critical juncture in career development, as students begin to form and narrow their perceived career options (Gottfredson, 2002). Early, engaging interventions that spark interest and build self-confidence are essential for expanding students' awareness and strengthening the STEM pipeline.

National education policies such as Perkins V (2018) and Career and Technical Education (CTE) frameworks emphasize the need for early access to career exploration for all student groups, including those

underrepresented in STEM. However, traditional models of career exploration-such as field trips, job shadowing, and guest speakers-often require time, funding, and community partnerships that many schools lack. Game-based learning (GBL) is a scalable alternative that simulates real-world roles in interactive digital environments where students can safely experiment, fail, and try again (Emihovich, Arrington, & Xu, 2019).

Well-designed games engage students through voluntary, intrinsically motivated play that supports cognitive development and career exploration (Klopfer et al., 2009; Shute et al., 2019). Within GBL settings, students perform structured problem-solving tasks to achieve goals in immersive, rule-based scenarios. This blend of autonomy, challenge, and narrative creates conditions for deep learning, where students generate and apply knowledge while refining their thinking. Research has demonstrated GBL's effectiveness in high school chemistry (Petrovich et al., 2020), STEM education (Shah et al., 2019; Barany et al., 2017, 2019), and cybersecurity training in higher education (McDonald et al., 2019; Giboney et al., 2019, Jin et al.,2018). Yet, there remains limited research on how GBL can support middle school students, particularly in exploring STEM careers in health sciences.

Motivational and cognitive learning theories provide a useful framework. According to Mayer (2019), five motivational theories help explain sustained engagement in GBL environments: interest, self-efficacy, goal orientation, intrinsic motivation, and social cues. This study focuses on *interest theory* and *self-efficacy theory*, both of which are directly aligned with the research questions. Interest theory posits that students are more likely to engage when content is personally meaningful (Schiefele, 2009; Mayer, 1998), while self-efficacy theory asserts that learners build confidence through repeated mastery of challenging tasks (Bandura, 1997; Bandura *et al.*, 1999). Interest itself remains an underdefined yet essential construct in educational research (Parong & Mayer, 2018).

GBL environments are particularly well-suited to support these motivational processes. Games offer "pleasantly frustrating" challenges that keep learners operating at the edge of their abilities (Gee, 2003), creating opportunities for trial-and-error learning and confidence-building. For example, Ross et al. (1985) found that students retained more knowledge when content was linked to their future careers, reinforcing the role of relevance in promoting learning and motivation (Mayer, 2008).

This study investigates whether *End of Imperial*, an online medical mystery game featuring diverse STEM professionals, can enhance middle school students' interest in health science careers and strengthen their self-efficacy in STEM learning. In the game, students take on the role of a detective working alongside healthcare and science professionals, forensic investigators, and prosecutor to solve a complex motor vehicle collision. Through gameplay, students engage in evidence gathering, critical thinking, and scientific reasoning. Using post-gameplay surveys, this study explores how these immersive problem-solving experiences shape students' motivation, confidence, and career perceptions, contributing to the broader conversation on how GBL can expand access to and interest in the STEM workforce of the future.

2. Methods

We examined the impact of a serious digital learning game on middle school students' interest in STEM careers, particularly health sciences. Grounded in Mayer's interest (Mayer, 2014) and Bandura's self-efficacy theory (Bandura, 1997), our study assessed the effect of an interactive, narrative-based learning game on middle school students' interest, motivation, engagement, and learning across 3 distinct school environments. These school sites included Title I and non-Title I schools, offering a diverse representation of participating students.

2.1 Participants

A total of N = 86 middle school students. Students were drawn from an urban public school (UP, n = 29), an urban charter school (UC, n = 18), and a suburban public school (SUP, n = 39) (see Table 1).

Table 1: Participant site demographics for urban public (UP), urban charter (UC), suburban public (SUP)

Race/Ethnicity	Urban Public	Urban Charter	Suburban Public
% Black	10.3	59.9	2.5
% Latino	86.2	24.7	1.1
% Asian	6.9	9.4	28.8
% White	13.8	29.1	46.7
School Statistics			

Race/Ethnicity	Urban Public	Urban Charter	Suburban Public
% Black	10.3	59.9	2.5
% Latino	86.2	24.7	1.1
% English Language Learners	8.1	18.6	3.9
% Free/Reduced Lunch	60.8	87.9	5.8

All students participated during regular class periods and received the same access to the game. Participation was voluntary. No personally identifiable data were collected in accordance with ethical research standards.

2.2 Game Design, Description and Technical Specifications

To support inquiry-based exploration of STEM careers and increase health awareness, the authors developed *End of Imperial*, a web-based neo-noir mystery game, designed as a point-and-click adventure. It was built using JavaScript and HTML. The game runs in the Chrome browser with a minimum screen resolution of 1024×768 pixels. The game was intentionally optimized for classroom environments, including Chromebooks and Windows laptops commonly found in schools, ensuring compatibility without requiring additional software installation. All that was needed to play the game was a Chrome browser and internet access.

In the game, students play the role of a detective to determine the cause of death for a high-profile celebrity using medical and forensic data. The game narrative unfolds through 13 interactive scenes, each requiring players to collect evidence, conduct interviews, and interpret data to move forward in the investigation, mirroring real-world interdisciplinary STEM practices.

Gameplay incorporates authentic terminology and procedures from multiple STEM careers, including forensic pathology, emergency medicine, toxicology, and digital forensics. This immersion in professional roles is intended to support career awareness and explorations while deepening conceptual understanding of topics related to sleep hygiene.

To ensure broad accessibility, the game was tested across devices in different school environments. At the UP and UC schools, students used 3- to 4-year-old Dell Latitude laptops running Windows. Students at the SUP school used 2-year-old HP Chromebooks. All schools were equipped with Wi-Fi 4 (802.11n) and had dedicated wireless access points in each classroom. No gameplay interruptions or technical performance issues were reported during implementation.

2.3 Procedure

The study was implemented over 2 consecutive school days. On Day 1, students were introduced to the game and began playing from the initial investigative scenes. On Day 2, students resumed the game and completed the remaining scenes. Total gameplay time across the two sessions was about 90 minutes. Immediately after playing the game, students completed an anonymous online survey assessing their experience. The survey was hosted on a secure digital platform. Confidentiality was strictly maintained. Students were instructed not to include names. Any personally identifiable information entered was removed before analysis.

2.4 Survey Design and Learning Constructs

The survey was structured around 3 key learning constructs:

1. *Interest in STEM careers*: intrinsic curiosity and motivation students felt toward science and health professions following gameplay. As players progressed through the game, they engaged with a cast of STEM professionals who collaborated to investigate the crash, collect the evidence and complete forensic analysis. The use of authentic data formats and role-based problem-solving supported students' interest in health and science careers. These game-based interactions provided repeated opportunities to practice skills associated with real-world professions, making abstract STEM concepts tangible and engaging (see Figure 1).
2. *Self-efficacy*: students' confidence in their ability to learn and apply STEM concepts while solving in-game challenges. Throughout gameplay, students confronted challenges that required them to interpret evidence, solve problems, and draw conclusions. Players also observed the effects of sleep deprivation on their own detective character, reinforcing key messages about sleep health. These iterative problem-solving tasks provided students with a sense of mastery, consistent with Bandura's theory that self-efficacy increases through success in progressively difficult tasks (Bandura, 1997).

Students also demonstrated rule acquisition and problem-solving through the application of in-game tools and logical reasoning (Emihovich, Roque, & Mason, 2020).

3. *Purpose* or the perceived educational value of the game experience, including whether the content felt meaningful, worth-while, and connected to real-world applications. While solving the case, students were required to formulate and present a theory of what happened to the Deputy District Attorney. The in-game quest system, initially embedded in an evidence log, was later redesigned to appear in a separate task list to enhance usability. This shift reflected a common classroom challenge: balancing unstructured learning tasks that give agency to gameplay against a guide that makes the game's educational objectives more transparent. Purpose was reinforced by the game's real-world framing: players had to act like investigators and justify conclusions using data, reflecting practices found in STEM careers.

These constructs were grounded in well-established motivational learning theories, specifically, Mayer's interest (Mayer, 2014) and Bandura's self-efficacy theory (Bandura, 1997). Table 2 presents the alignment between each learning construct, its definition, and example of survey response.

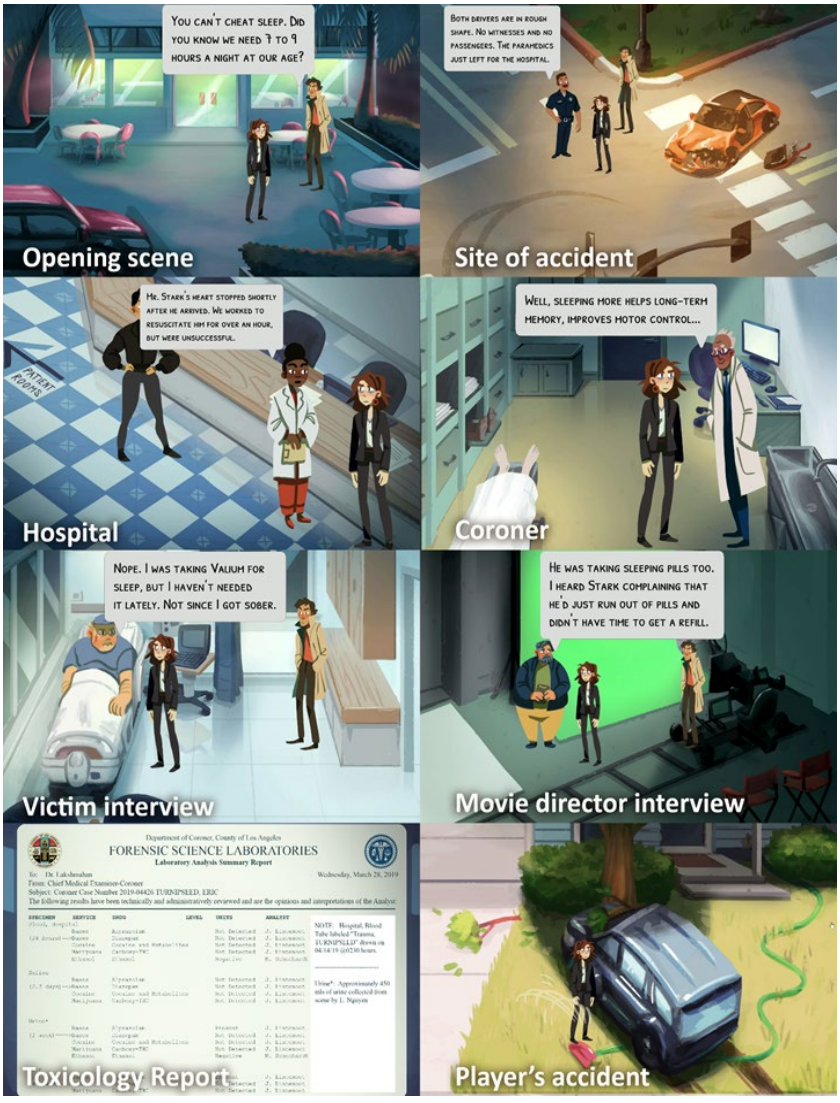

Figure 1: A screenshot of authentic scenes encountered during gameplay

Table 2: Learning construct, description, and survey response example

Learning Construct	Description	Example of survey items
Interest	Intrinsic curiosity and motivation of the student towards science and health career	My interest in science increased My interest in health careers increased
Self-efficacy	Confidence and enjoyment of the student while solving the mystery and using scientific reasoning	My confidence in science increased I liked this mystery game
Purpose	Perceived value, learning and challenge level of the game	I learned a lot This mystery game was difficult

The post-game survey included 4 key Likert-scale items:

- *"My interest in health science careers increased"*: measuring career motivation toward science and health careers.
- *"I liked the mystery game"*: measuring enjoyment and engagement with the game.
- *"I learned a lot":* assessing perceived learning, i.e. self-assessed knowledge gain.
- *"This mystery game was difficult"*: gauging perceived challenge level.

The survey included multiple Likert-scale items for each construct, ensuring measurement precision and reliability. Survey items were adapted from prior work in game-based learning research and covered both the affective and cognitive aspects of student experience (Cameron & Bizo, 2019; Jin et al., 2018]. While full self-efficacy data were limited, the item *"I learned a lot"* served as a proxy measure of perceived mastery and engagement.

A 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) was used to assess interest in STEM careers, self-efficacy in STEM learning, and the perceived purpose of gameplay. These items aligned with Mayer's (triggering and sustaining interest) and Bandura's theory (emphasizing mastery through engagement and feedback).

In addition to Likert items, the survey included open-ended questions designed to provide additional information on what students learned and how the game affected their interest in science and health careers. Open-ended questions allowed students to elaborate on their responses, yielding additional qualitative insights.

2.5 Data Collection and Instrument Validation

Students entered their responses in an online survey immediately after gameplay. To assess the internal validity of the survey, factor analysis was conducted to determine whether survey items appropriately grouped under each construct: interest, self-efficacy, and purpose. The factor structure was examined to confirm that items aligned with the study's motivational learning framework, based on Mayer's interest and Bandura's self-efficacy theory. To assess the reliability of the survey, Cronbach's alpha was calculated for each construct, ensuring internal consistency in measuring STEM career interest, self-efficacy, and purpose. These steps confirmed that the survey instrument aligned with the study's theoretical framework and was appropriate for measuring students' motivational responses to the game experience.

2.6 Statistical Analysis

Quantitative data analysis included descriptive statistics, internal consistency checks, and group comparisons. A one-way analysis of variance (ANOVA) was used to detect differences across school settings for each of the three learning constructs. Levene's test for homogeneity of variance was applied to verify that assumptions for ANOVA were met. Effect sizes (Cohen's f) were calculated to supplement significance testing and provide insight into the magnitude of any observed differences. This statistical approach allowed the researchers to evaluate not only whether students' motivation varied by school type, but also the extent to which the game-based intervention influenced attitudes toward STEM learning across diverse educational contexts.

Descriptive statistics and one-way ANOVA were used to compare responses across school sites. The independent variable was school setting (UP, UC, SUP), and the dependent variables were the four survey items. Levene's test confirmed homogeneity of variance. Where p-values approached or met significance ($p \leq .05$), Cohen's f was

used to estimate effect sizes. While confidence was not directly measured with sufficient resolution, responses to "I learned a lot" and "My interest in health science careers increased" served as indirect indicators of engagement and developing science identity, consistent with the literature on self-efficacy and vocational interest.

3. Results

After playing *End of Imperial*, middle school students reported gains in interest, learning, and self-efficacy related to STEM careers. Students from all 3 participating school sites—UP, UC (both Title I), and SUP-demonstrated consistent engagement with the game and positive perceptions of its educational value.

Based on our theoretical framework, survey items captured 4 key outcome areas: interest, learning (purpose), perceived difficulty, and enjoyment (engagement). These were aligned with Mayer's interest and Bandura's self-efficacy theory. Interest was assessed as a measure of engagement in health and science careers, while confidence was measured in relation to understanding science concepts. Perceived learning gains were used as a proxy for self-efficacy.

Survey results, as illustrated in Figure 2, indicate that students not only enjoyed the game but also reported substantial learning gains and increased confidence in STEM-related topics.

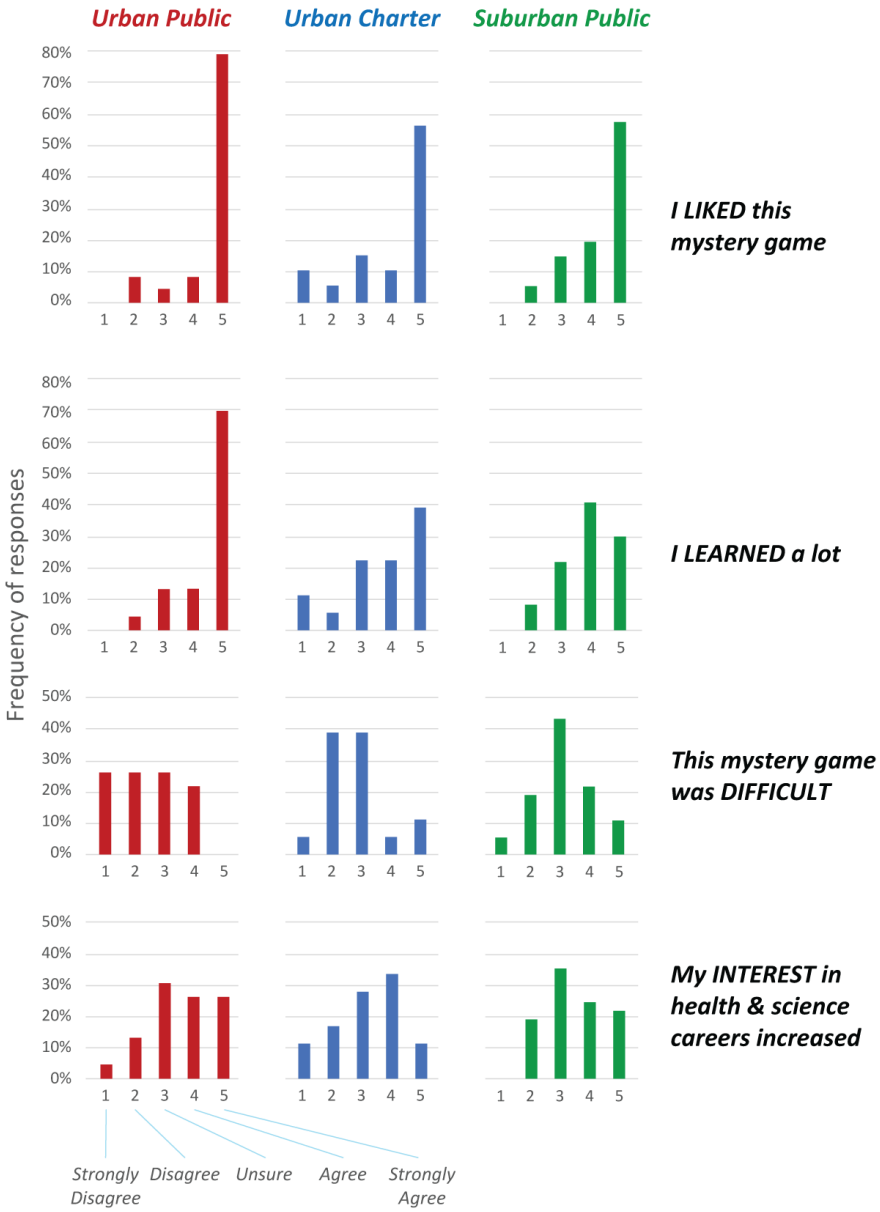

Figure 2: Survey results from 86 middle-school students from three school districts in California

3.1 Enjoyment and Engagement: "I Liked the Mystey Game"

Students at all 3 school sites rated the game highly enjoyable, with mean scores ranging from 3.9 - 4.6. The UP school students reported the highest average enjoyment. However, there was no significant difference in means (F (2,75) = 1.691; p = 0.191).

91% of students at UP, 83% at UC, and 95% at SUP rated the mystery game 3-5. Overall, students **enjoyed** playing the game at all three school sites. These results suggest that *End of Imperial* successfully engaged students across diverse school settings.

3.2 Learning and Perceived Purpose: "I learned a lot"

Students reported substantial learning gains. Students at the UP school reported the highest learning gain (mean = 4.48) which is higher than the other two sites (3.72 UC and 3.92 SUP). Using an alpha of 0.05, this difference was significant (F(2,75) = 3.173; p = 0.048). Future studies will look into possible explanations for this difference. 96% of students at UP, 84% at UC, and 92% at SUP school reported self-perceived learning gains as 3, 4 or 5. These substantial learning gains are used as a proxy for increased confidence in STEM-related topics.

3.3 Difficulty Level and Perceived Challenge: "This Mystery Game was Difficult"

Students at the high-performing SUP school reported a mean hig (3.14) compared to the other two sites (2.43 UC and 2.78 UP). This difference was statistically significant (F(2,75) = 3.114; p= 0.05). Difficulty level of 3-5 was reported by 48% of students in UP, 56% of students at UC, and 76% of students at SUP schools.

3.4 Career Interest: "My Interest in Science and Health Careers Increased"

Results across all locations showed a significant increase in health and science career interest. There was no significant difference in means (ranging from 3.17 to 3.57) across all three sites (F(2,75) = 0.716; p = 0.492). 83% of students at UP, 72% of students at UC, and 81% of students at SUP schools reported their interest level 3-5.

These findings indicate that the game was effective in stimulating health and science career interest across diverse student groups, aligning with Mayer's interest theory.

Table 3: Overall survey results by each school location

	Urban Public			Urban Charter			Suburban Public			1-way ANOVA		Cohen's
	n	Mean	Var	n	Mean	Var	n	Mean	Var	*F*	*p*	*f*
I ***liked*** this mystery game	23	4.57	0.89	18	3.94	2.06	37	4.3	0.88	1.691	0.19	0.21
I ***learned*** a lot	23	4.48	0.81	18	3.72	1.86	37	3.92	0.85	3.173	0.05	0.29
This mystery game was ***difficult***	23	2.43	1.26	18	2.78	1.12	37	3.14	1.06	3.114	0.05	0.29
My ***interest*** in science & health careers increased	23	3.57	1.35	18	3.17	1.44	37	3.49	1.09	0.716	0.49	0.14
	86.2% Latino			***59.9% Black***			***46.7% White***					

3.5 Health Awareness and Science Application

Students not only enjoyed the game but also reported substantial learning gains and increased confidence in science. In addition, students' awareness of healthy sleep habits, a key theme in the mystery, was increased. A majority of students reported they would try to get more sleep after playing the game, highlighting the game's impact on real-world health behaviour awareness. Students were also introduced to scientific roles (e.g., toxicologists, medical investigators, forensic specialists) through immersive scenarios involving sleep deprivation and prescription drug misuse.

3.6 Factor Analysis and Qualitative Insights

Factor analysis further confirmed that survey responses clustered appropriately under each construct, supporting the internal validity of the instrument. Cronbach's alpha across questions 1, 2, and 4 was 0.86, indicating good internal consistency of the survey items. Although direct confidence measures were limited, high ratings on the *"I learned a lot"* item and open-ended feedback suggest increased perceived self-efficacy in STEM topics.

Additionally, the survey included open-ended responses, where students elaborated on how gameplay influenced their interest in STEM careers, reinforcing the quantitative findings and providing deeper insight into the impact of game-based learning on career motivation. Students described feeling "like a real detective," and many expressed curiosity about careers in science, medicine, or investigation. Several mentioned learning new information about sleep and health science topics, indicating both cognitive and affective engagement.

These findings align with our research question, demonstrating that GBL can enhance students' STEM career interest and self-efficacy. The significant increase in confidence and motivation supports Mayer's interest theory and Bandura's self-efficacy framework, reinforcing the role of interactive learning in shaping career aspirations.

4. Discussion

This study examined middle school students' responses to *End of Imperial*, a digital medical mystery game designed to promote interest, engagement, and self-efficacy in STEM and health science careers. Grounded in Mayer's Interest Theory and Bandura's Self-Efficacy Theory, the game leverages narrative-based gameplay and problem solving to embed academic and behavioural health content—specifically sleep—into an immersive learning experience.

Findings across three diverse school settings, including two Title I schools, indicate that students not only enjoyed the game but also perceived significant learning gains. Over 80% of students expressed an increased interest in science and health careers. These outcomes suggest the game successfully sparked situational interest (Mayer) and provided mastery-like experiences that contribute to self-efficacy (Bandura), for diverse groups of students. While direct confidence measures were limited, self-reported learning served as a useful proxy for perceived competence and engagement.

Students found the mystery-solving elements and storyline meaningful and engaging. The connection between sleep habits and real-life consequences—framed through the lens of a fatal car crash investigation—brought relevance to an abstract health topic while supporting critical thinking and decision-making. These elements align with research showing that real-world context and student agency enhance motivation and retention. Usability feedback highlighted the need for more onboarding and scaffolding, especially for journal navigation and argument construction. Addressing these areas could reduce cognitive load and improve outcomes across diverse learners.

Additionally, this study contributes to the literature on serious games in health and STEM education by demonstrating that well-designed, culturally relevant, story-driven games can engage diverse learners. It also reinforces the value of integrating behavioral health themes—like sleep—into STEM career education.

4.1 Perceived Limitations

This study relied on post-survey self-reports without pre-survey or control group comparisons, limiting our ability to measure actual change or isolate the game's specific impact. Results reflect immediate perceptions and do not capture longer-term learning or behavior change. While the school sample was diverse, it may not be representative of all populations. No objective academic or health outcomes were measured. Future studies should incorporate control conditions, pre/post data, and longitudinal tracking.

4.2 Implications for Educators, Schools, and Policymakers

These results indicate that serious games like *End of Imperial* can be effective tools for engaging middle school students in STEM and health-related learning, especially in settings where experiential opportunities are limited. For educators, the game offers a flexible, easy-to-implement, standards-aligned resource that encourages inquiry and career exploration without requiring specialized training or technology/hardware.

Schools and districts may integrate serious games into science, health, or electives curricula to complement instruction and support interest in future careers. Narrative-driven games that reflect students' lived experiences may help bridge gaps and broaden access to meaningful STEM learning.

For policymakers and education leaders, this study highlights the importance of investing in scalable, evidence-based educational innovations that combine academic content with health and career relevance. Tools like *End of Imperial* may serve as critical components in early STEM pipeline efforts and public health literacy campaigns, especially when implemented at the middle school level—a key stage for identity and interest formation.

4.3 Conclusion

In conclusion, *End of Imperial* demonstrates how serious games can be thoughtfully designed to align with established learning theories while addressing both academic and behavioral health goals. By embedding real-world relevance into engaging gameplay, the game fosters interest, motivation, and perceived learning across a range of student populations. While additional research is needed to explore long-term outcomes and implementation models, this study affirms the potential of game-based learning to contribute meaningfully to equitable STEM education and early career awareness. Embedding these tools in middle school education may yield long-term benefits for both individual learners and workforce development.

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Data Availability Statement: the data for this study are available upon request from the authors.

Ethics Declaration: review by an institutional review board determined this study qualified as exempt human subjects research under 45 CFR 46.104 (d) (1), for research conducted in established educational settings.

Conflicts of Interest: Ben Emihovic and Nelson Roque have no conflicts of interest. Dr. Jasminka Vukanovic-Criley and Stuart Criley are employed by Indelible Learning. Williams Criley, Richard Criley, and Jasmine Alagoz are current or former interns at Indelible Learning.

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