

Enhancing Vocational Training Through Immersive Technology: A Study on Digital Magic Mirrors

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Abstract: This study explores the impact of digital magic mirrors on student engagement and skill development in vocational education, specifically in the hospitality sector. Traditional classroom-based instruction often fails to connect theoretical knowledge with practical application, leading to insufficient preparation for industry demands. To address this, the research integrates a digital magic mirror into a digital theater room to enhance learning through immersive experiences. A quasi-experimental design involved 60 hospitality students divided into an experimental group using the digital magic mirror and a control group using a general digital learning approach. Learning achievement, engagement, and self-efficacy were measured through pre- and post-tests and a questionnaire. Results showed that the experimental group had significantly higher learning achievement compared to the control group. The digital magic mirror also improved student engagement and skill development. However, no significant differences were found in perceived learning motivation and self-efficacy, with both groups reporting positive experiences. These findings suggest that digital magic mirrors effectively bridge the theory-practice gap in vocational education by providing dynamic learning environments. The study concludes that the proposed digital magic mirror approach can significantly enhance student outcomes and recommends further research on their long-term impacts and broader applicability.

Keywords: Digital magic mirror, situational learning, immersive learning, engagement

1. Introduction

Vocational education and training, particularly in fields like hospitality, encompass both verbal and non-verbal elements. Verbal components include textbook language for greeting guests and taking orders, while non-verbal elements involve body language, facial expressions, posture, and gestures. Traditional classroom-based instruction, focused on textbook approaches, often fails to prepare students for the dynamic demands of the hospitality industry due to its limitations in providing practical, interactive experiences (Jiang & Alexakis, 2017). Several issues plague traditional vocational education. Theoretical knowledge is often disconnected from practical application, creating a gap in students' understanding and skills (Gonczi, 2020). Static learning environments fail to simulate the dynamic nature of real-world scenarios, crucial for vocational training (Chen, 2022). Traditional methods also lack support for deconstructing and analyzing movements, essential for mastering practical skills (Zhao, 2024). Additionally, there is often insufficient immediate feedback and guidance, critical for skill development (Maier & Klotz, 2022).

Despite advancements in digital learning, gaps persist. There is a disconnection between textbook knowledge and its representation in digital reality, necessitating a seamless integration between theoretical knowledge and its practical application in digital learning environments (Ravichandran & Mahapatra, 2023). The link between sensory perception and motor skills, crucial for effective vocational training, is often missing in traditional digital tools (Renganayagalu, Mallam, & Nazir, 2021). Immediate and actionable feedback, essential for vocational training, is frequently inadequate in traditional methods (Howell, 2021).

To address these gaps, this study proposes using a "digital magic mirror" in a digital theater room—a digital situational learning environment (Cai et al., 2020). This approach integrates principles from situated cognition and embodied cognition to create a more effective learning environment. Situated cognition posits that learning is embedded within authentic contexts mirroring real-world scenarios, enhancing the relevance and application of knowledge (Brown, Collins, & Duguid, 1989). Embodied cognition emphasizes the role of the body in learning, ensuring physical actions and movements are integrated into the learning process (Shapiro & Stolz, 2019).

Although technology-enhanced learning offers potential advantages, its effectiveness in vocational education, particularly in the hospitality and tourism sectors, requires further empirical evaluation. This study investigates the impact of the digital magic mirror learning approach on students' learning outcomes, motivation, and self-efficacy. Traditional digital learning approaches may not fully leverage the potential of immersive and interactive technologies to enhance vocational education. This study explores and evaluates an innovative digital learning tool, the digital magic mirror, potentially providing more engaging and effective educational experiences for students in the hospitality and tourism industries.

Two research questions guide this study: (1) Is there a significant difference in learning achievement between students using the digital magic mirror learning approach and those using a general digital learning approach? (2) Is there a significant difference in perceived learning motivation, learning effect, and self-efficacy between these two groups? The hypotheses are: (1) Students using the digital magic mirror learning approach will demonstrate significantly higher learning achievement compared to those using the general digital learning approach. (2) The digital magic mirror learning approach will result in higher levels of learning motivation, learning effect, and self-efficacy. This study aims to provide insights into the effectiveness of innovative digital learning tools in vocational education and offer recommendations for future research and practice.

2. Literature Review

2.1 Theoretical Framework: Constructivism and Situated Cognition

Constructivism and Situated Cognition are two influential learning theories that inform the design of effective learning environments in vocational education. Constructivism posits that learners construct their own understanding and knowledge through experiences and reflecting on those experiences (Piaget, 2013). This theory emphasizes active learning, where students engage directly with the material and develop practical skills through hands-on experiences, a critical component for vocational training.

Complementing Constructivism, Situated Cognition theory asserts that knowledge is inherently tied to the context in which it is learned and used (Brown, Collins, & Duguid, 1989). This theory highlights the importance of creating learning environments that closely replicate real-world scenarios, enabling learners to develop skills and knowledge directly applicable to their professional lives. Consequently, Situated Cognition underscores the need for contextually rich, immersive learning experiences to prepare students for the specific demands of their careers in vocational education.

The synergy between Constructivism and Situated Cognition informs the design of effective vocational education programs. A constructivist framework necessitates learning environments that encourage exploration, problem-solving, and critical thinking through project-based learning, simulations, and other hands-on activities. These activities allow students to engage with real-world problems and scenarios, actively constructing knowledge.

Building upon this foundation, Situated Cognition emphasizes the significance of authentic contexts. Learning activities should not only be interactive but also closely mirror the actual tasks and challenges students will face in their professional lives. For example, in hospitality education, simulated hotel management exercises, role-playing customer service scenarios, or using digital tools can recreate real-world settings.

The integration of Constructivism and Situated Cognition in digital immersive learning environments has garnered considerable research attention. Digital tools and technologies, such as virtual reality (VR) and augmented reality (AR), offer unprecedented opportunities to create interactive, immersive, and contextually rich learning experiences. These technologies can simulate real-world environments and scenarios, providing students with practical, hands-on experience in a controlled setting.

Recent studies have demonstrated the effectiveness of these approaches. Kim et al. (2020) found that VR simulations in vocational training programs significantly enhanced students' engagement and learning outcomes by providing realistic, immersive experiences that traditional methods could not match. Similarly, Dede (2014) highlighted the potential of AR in creating situated learning experiences that foster deep understanding and practical skill development.

Moreover, Mayer (2019) emphasized the role of multimedia learning in enhancing cognitive processes. By integrating text, audio, and visuals, multimedia tools can support constructivist learning by facilitating the active construction of knowledge. These tools also align with the principles of Situated Cognition by embedding learning in authentic contexts. In summary, the theoretical frameworks of Constructivism and Situated Cognition provide a robust foundation for developing vocational education programs that are both engaging and effective. By integrating these principles with advanced digital technologies, educational experiences can be designed to promote active learning, problem-solving, critical thinking, and the development of practical skills within authentic, contextually rich environments.

2.2 Embodied Cognition and Situated Learning Environment

Embodied Cognition is a theory positing that cognitive processes are deeply rooted in the body's interactions with the world. This perspective suggests that cognition is not solely a product of the brain but is also influenced by the body's movements, sensory experiences, and physical interactions (Wilson, 2002). Embodied Cognition has significant implications for vocational education, particularly in training non-verbal skills crucial in fields like hospitality and tourism, such as body language, gestures, and spatial awareness. Understanding embodied cognition helps educators design training programs that incorporate physical actions and sensory experiences, which are essential for mastering these non-verbal skills.

Embodied cognition informs the design of situated learning environments by emphasizing the importance of physical engagement and contextual learning. Situated learning environments are those where knowledge and skills are acquired in the same context in which they will be applied (Lave & Wenger, 1991). In vocational education, this translates to creating environments where learners can interact with real-world tools and scenarios. By incorporating principles of embodied cognition, these environments can enhance learning by ensuring that cognitive processes are supported by physical actions and sensory experiences. For instance, in hospitality training, students can practice setting tables, serving customers, or managing a front desk in a simulated environment that mimics real-world conditions, embedding learning in a context that closely resembles actual job tasks.

Technology plays a crucial role in creating immersive and interactive situated learning environments. Digital immersive learning environments and 3D cameras are some of the technologies being integrated into vocational education to enhance skill development and industry readiness. Virtual Reality (VR) and Augmented Reality (AR) provide immersive experiences that allow students to practice skills in a controlled, yet realistic setting, simulating complex scenarios like customer interactions or emergency responses (Kim et al., 2020). 3D cameras enhance the realism of simulations by capturing detailed movements and interactions, enabling more precise feedback and assessment, particularly useful in training scenarios

where spatial awareness and precise movements are crucial, such as in culinary arts or event management.

The integration of these technologies into vocational education has several benefits. It enhances engagement by providing interactive and realistic training experiences, facilitates immediate feedback, and allows for repeated practice without the constraints of a real-world setting. However, challenges exist, including the high cost of technology, the need for technical support, and potential resistance from instructors and students accustomed to traditional training methods.

Empirical studies have examined the effectiveness of technology-enhanced learning approaches in vocational education. Mayer (2019) found that VR simulations significantly improved students' engagement and learning outcomes in hospitality training programs. Dede (2014) highlighted the potential of AR in creating immersive learning environments that enhance practical skill development. Additionally, Rocca et al. (2023) presented tools that can analyze and model trainer activity in simulation-based training, improving training for practical teaching gestures and civil defense by using 3D cameras.

In summary, the theory of Embodied Cognition, along with the principles of situated learning environments, provides a framework for designing effective vocational education programs that incorporate physical engagement, sensory experiences, and contextual learning. The integration of technologies like VR, AR, and 3D cameras offers opportunities to create immersive, interactive, and realistic training environments, enhancing skill development and industry readiness. While challenges exist, empirical evidence supports the effectiveness of these approaches in improving learning outcomes and practical skills.

3. Design and Development of the Digital Magic Mirror Learning System

3.1 System Development

To create dynamic learning scenarios within a digital situated learning environment and incorporate a freezing mechanism for describing static event structures, this study designed a digital magic mirror learning system. This innovative tool integrates a digital mirror with a screen display, allowing learners to view their own performance during demonstrations. The digital magic mirror learning system generates dynamic scenarios and can freeze dynamic events to display static images. These static images help analyze component structures and spatial positions within the event, facilitating learners' understanding and application of knowledge in dynamic contextual spaces.

3.2 System Architecture

As shown in Figure 1, several key features characterize the digital magic mirror learning system. The Digital Immersive Learning Environment creates an engaging, interactive, and experiential learning experience. The Digital Mirror displays correct expert body movements, providing visual feedback to learners. 3D Cameras accurately map the learner's body movements onto the digital mirror, enabling real-time comparisons and feedback. Furthermore, the system offers real-time feedback for Posture Correction and Guidance, assisting learners in refining their skills.

The digital magic mirror learning system offers numerous benefits. Its immersive and interactive nature significantly promotes student engagement and participation. Real-time feedback tailored to each learner's movements allows for personalized guidance and improvement. Moreover, the system facilitates the development of both verbal and non-verbal skills, such as communication, body language, and customer interaction, which are crucial in vocational education. Finally, the integration of visual feedback, experiential learning, and technology enhances the effectiveness and retention of learning.

By combining these advanced features and benefits, the digital magic mirror learning system creates an immersive and interactive learning environment while providing personalized feedback, which is essential for effective skill development in vocational education, particularly in the fields of hospitality and tourism. This innovative approach

addresses the need for dynamic and context-rich learning scenarios, ensuring learners gain practical skills and industry readiness.

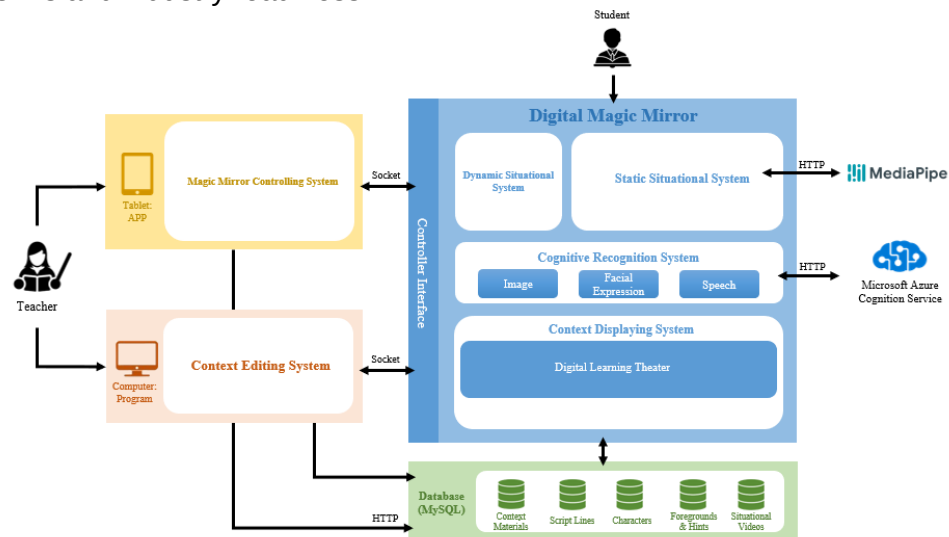


Figure 1. The System Architecture of the Digital Magic Mirror Learning System

4. Research Method

4.1 Participants

This quasi-experimental study was conducted at a science and technology university in northern Taiwan, involving participants from two classes within the hospitality practical course. One class was randomly assigned to the experimental group, while the other served as the control group. A total of 60 students participated, with an average age of 21 years old. Notably, most participants had limited or no prior experience in hospitality practice. The experimental group comprised 30 students (16 males and 14 females), while the control group consisted of 30 students (10 males and 20 females).

4.2 Learning Content

The learning content, developed by two senior instructors with over ten years of teaching experience in the course, focused on both verbal and non-verbal communication skills essential for effective service in the hospitality industry for workers who require proficiency in Japanese. The verbal communication training concentrated on mastering Hospitality Japanese, enabling students to interact with guests clearly and courteously using appropriate language. For instance, students practiced phrases such as 'Irasshaimase' (welcome) during greetings and 'Arigatou gozaimasu' (thank you very much) during farewells, ensuring a warm and professional service experience."

Non-verbal communication training was equally emphasized, focusing on proper body movements, serving techniques, and maintaining a professional appearance (Kim & Ok, 2009; Pizam & Shani, 2009). For example, a component was the practice of bowing, a fundamental aspect of showing respect in Japanese culture. Students learned the "eshaku" (slight bow) for informal greetings and the "keirei" (medium bow) for formal farewells, thereby mastering respectful gestures towards guests (Coulmas, 2013). This combination of verbal and non-verbal training ensured students were well-prepared to meet the high standards of the hospitality industry, enhancing their overall professional competence and employability.

4.3 Experimental Procedure

The experiment spanned four weeks and was structured around the proposed learning model, as illustrated in Figure 2. Before beginning, both groups were introduced to the learning systems and tasks, and all students completed pre-tests to assess their baseline learning achievement.

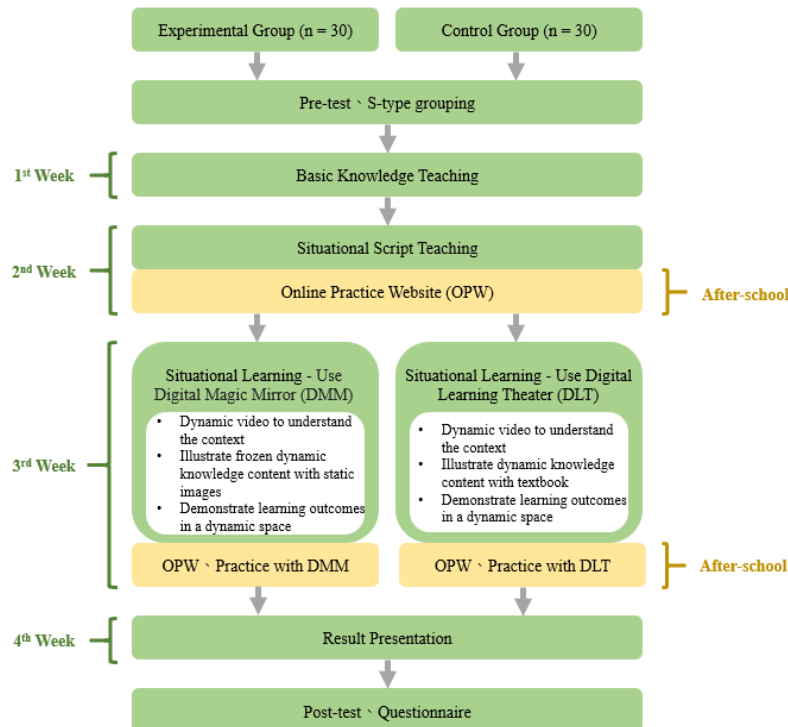


Figure 2. Experimental Procedure

The experimental and control groups followed identical procedures, using the same learning materials and being taught by the same instructor. The study time was divided into classroom learning and after-class exercises. During classroom learning, the experimental group utilized the digital magic mirror learning system, designed based on the principle of action-shaping thinking, to facilitate learning in Hospitality Japanese and hospitality-related knowledge. Conversely, the control group used a general digital learning theater to cover the same content. Weekly classroom sessions involved group-based script performances, with students organized into S-shaped groups according to their pre-test scores to ensure balanced group abilities.



Figure 3. Situational Instructional Video



Figure 4. The Demonstration Portrait



Figure 5. Feedback to the Incorrect Gesture



Figure 6. Feedback to the Correct Gesture

For after-class practice, the experimental group continued to use the digital magic mirror learning system to practice movement skills. This included watching dynamic situational instructional videos, freezing key scenes to illustrate spatial structures, and using static demonstration portraits to guide postures and movements (see Figures 3-6). The system provided immediate feedback on movement accuracy. The control group used a general digital learning theater, watching dynamic instructional videos and performing actions directly. Both groups accessed an online practice website to review materials and complete quizzes, monitoring their learning progress. At the end of the four-week period, both groups completed post-tests on learning achievement and questionnaires assessing learning motivation, learning effect, and self-efficacy.

4.4 Measurement Tools

The measurement tools comprised learning achievement tests (pre- and post-tests) and a questionnaire assessing user perceptions of learning motivation, benefits, and self-efficacy. The pre- and post-tests, designed by experienced senior instructors, encompassed verbal and non-verbal sections, with a maximum score of 100 points. The verbal section focused on Hospitality Japanese, while the non-verbal section centered on body postures and gestures commonly employed in restaurant and hotel services. The pre-test evaluated students' prior knowledge, while the post-test assessed the knowledge acquired during the experiment.

To evaluate students' perceptions, a questionnaire based on the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, et al., 1991) and the Attention, Relevance, Confidence, Satisfaction (ARCS) model (Keller, 1987) was designed. The questionnaire consisted of eleven items: four items assessed learning motivation, three items evaluated learning effect, and four items measured self-efficacy. All items were positively stated and rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire demonstrated high internal consistency, with a Cronbach's alpha value of 0.947.

4.5 Data Analysis Tools and Methods

IBM SPSS Statistics version 20 was used for data analysis. To analyze the pre- and post-test data on learning achievement, ANCOVA (Analysis of Covariance) was employed, ensuring that observed differences in post-test learning achievement were attributable to the intervention rather than pre-existing differences between the groups (Field, 2013). For the questionnaire data, an independent *t*-test was conducted to compare the means of the experimental and control groups and determine if there was a statistically significant difference between them (Gravetter & Wallnau, 2017).

5. Results and Discussion

5.1 Learning Achievement

To investigate the effects of the proposed digital magic mirror learning approach, a one-way analysis of covariance (ANCOVA) was conducted. The pre-test scores of learning achievement were used as the covariate, the learning approach (digital magic mirror learning vs. general digital learning) as the independent variable, and the post-test scores of learning achievement as the dependent variable. Prior to conducting the ANCOVA, the assumption of homogeneity of regression slopes was tested and validated, showing no significant difference ($F = 1.375, p = 0.245$), allowing the use of ANCOVA for the analysis.

The ANCOVA results indicate that the original post-test mean scores for the experimental group ($n = 30$) and control group ($n = 30$) were 78.58 (SD = 13.19) and 71.41 (SD = 11.05), respectively. After excluding the impact of the pre-test scores on the post-test, the adjusted post-test mean scores for the experimental group ($n = 30$) and control group ($n = 30$) were 77.95 (SE = 2.06) and 72.05 (SE = 2.06), respectively. In addition, a statistically significant difference was found between the two groups' post-test scores ($F = 4.07, p = 0.048$),

with a medium effect size ($\eta^2 = 0.067$) according to Cohen (2013). These findings suggest that students using the digital magic mirror learning approach significantly outperformed those using the general digital learning approach, implying that the magic mirror can enhance learning outcomes more effectively.

The significant improvement in learning achievement, evidenced by the higher adjusted mean scores for the experimental group, highlights the efficacy of the digital magic mirror learning approach. The medium effect size underscores the meaningful educational impact of this innovative method. By leveraging interactive and immersive features, the digital magic mirror learning approach can significantly enhance student engagement and academic outcomes, aligning with previous research suggesting that such technologies can positively influence educational experiences (Kim et al., 2020; Mayer, 2019).

These results demonstrate the potential of the digital magic mirror learning approach to transform educational practices and enhance student achievement. By providing dynamic and engaging learning environments, educators can create more effective learning experiences that significantly improve academic performance. The unique features of the magic mirror, such as interactive and dynamic learning environments, empower educators to bridge the gap between theoretical knowledge and practical application, ultimately leading to improved learning outcomes for students.

5.2 Learning Motivation, Learning Effect, and Self-Efficacy

To assess the impact of the digital magic mirror learning approach on students' perceptions of learning motivation, learning effect, and self-efficacy, a t-test was conducted between the experimental group ($n = 30$) and the control group ($n = 30$), based on the questionnaire results. The experimental group, which utilized the magic mirror, showed a mean learning motivation score of 4.23 ($SD = 0.59$), while the control group, using a general digital learning approach, had a slightly lower mean score of 4.12 ($SD = 0.80$). In terms of the learning effect, the experimental group reported a mean score of 4.27 ($SD = 0.60$), while the control group scored 4.24 ($SD = 0.76$), indicating very similar outcomes. When examining self-efficacy, the experimental group again scored higher, with a mean of 4.19 ($SD = 0.65$), compared to the control group's mean of 3.88 ($SD = 0.96$).

Despite these positive mean scores, the independent samples t-test revealed no statistically significant differences between the experimental and control groups in terms of learning motivation, learning effect, or self-efficacy. This finding suggests that while both approaches were well-received, the addition of the magic mirror did not lead to a significant difference in students' perceptions compared to the general digital learning approach.

The analysis of students' perceptions regarding learning motivation, learning effect, and self-efficacy revealed no significant differences between the experimental group (using the digital magic mirror learning approach) and the control group (using the general digital learning approach). However, both groups exhibited positive responses across all three constructs. These findings have several implications, potential reasons, and recommendations for future research.

The high mean scores for learning motivation, learning effect, and self-efficacy indicate that students responded positively to both learning approaches. This positive reception suggests that both the digital magic mirror learning approach and the general digital learning approach are effective in engaging students and supporting their learning, aligning with previous research on the importance of interactive and technologically enhanced learning environments (Mayer, 2019; Dede, 2014).

The lack of significant differences between the two groups can be interpreted in various ways. First, the results may suggest that the general digital learning approach used in the control group is equally effective as the digital magic mirror learning approach in motivating students, enhancing learning effects, and improving self-efficacy. This equivalence could stem from the robustness of the general digital learning approach, which may already incorporate many effective educational strategies.

Second, the four-week implementation period may not have been long enough for the full benefits of the digital magic mirror learning approach to become apparent. Additionally,

students' familiarity with the general digital learning approach could have positively influenced their perceptions due to a comfort level with the traditional approach.

Finally, the instruments used to measure learning motivation, learning effect, and self-efficacy might not have been sensitive enough to detect subtle differences between the two groups. Future studies could benefit from using more nuanced or domain-specific measures to capture the impact of different learning approaches more accurately.

6. Conclusions, Limitations and Suggestions

This study evaluated the impact of the digital magic mirror learning approach on students' learning achievement, motivation, learning effect, and self-efficacy compared to a general digital learning approach. The analysis revealed that students in the experimental group, who used the digital magic mirror learning approach, achieved significantly higher post-test scores in learning achievement than those in the control group, indicating the effectiveness of the digital magic mirror learning approach in enhancing learning outcomes. However, the questionnaire results showed no significant differences between the two groups in terms of learning motivation, learning effect, and self-efficacy, although both groups reported positive perceptions.

While the findings suggest that the digital magic mirror learning approach improves learning achievement, both approaches are equally effective in maintaining high levels of motivation, perceived learning effect, and self-efficacy. These results have important implications for educational practice and the integration of technology in learning environments. The significant improvement in learning achievement with the digital magic mirror learning approach suggests that interactive and immersive technologies can enhance student learning outcomes. Educators and instructional designers should consider incorporating such technologies to create dynamic and engaging learning experiences. The positive responses from both groups regarding learning motivation, learning effect, and self-efficacy highlight the importance of fostering supportive and motivating learning environments, regardless of the specific technological tools used.

This study has several limitations. The sample size was relatively small and limited to a specific educational context, which may affect the generalizability of the findings. The study duration of four weeks may not be long enough to capture the long-term effects of the digital magic mirror learning approach. Additionally, the use of self-reported data to measure learning motivation, learning effect, and self-efficacy could introduce biases related to students' perceptions.

Future research should address these limitations by including larger and more diverse samples to enhance the generalizability of the findings. Longitudinal studies are needed to examine the long-term impact of the digital magic mirror learning approach on various educational outcomes. Additionally, future research should explore the specific features and mechanisms of the digital magic mirror technology that contribute to its effectiveness and investigate its applicability across different subjects and educational settings. Mixed-methods research incorporating both quantitative and qualitative data would provide a more comprehensive understanding of the impacts and experiences associated with the digital magic mirror learning approach.

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