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A Serious Game for Mould Prevention Education: A Comparative Study With Video-Based Learning

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ABSTRACT

Background: Indoor mould growth poses a significant risk to occupant health and building durability, particularly in climates with high humidity and inadequate ventilation. Traditional educational approaches often struggle to maintain learner engagement and support long-term behaviour change.

Objectives: This study presents the development and evaluation of alternative game-based learning to enhance learning outcomes, user motivation, self-efficacy, task load, system usability, knowledge retention, and behavioural change compared to video-based learning. The data were collected in three stages, including pre-test, post-test, and after 4 weeks.

Methods: Articulate Storyline 360 was used for developing the game. A between-subjects experimental design was conducted with 120 participants randomly assigned to either a game or video learning intervention.

Results and Conclusions: Both interventions produced significant immediate knowledge gains. The serious game demonstrated superior long-term knowledge retention and higher intrinsic motivation, supported by lower perceived task load and higher system usability. Self-efficacy improved under both conditions. No significant difference in self-reported behavioural change was observed after 4 weeks. Beyond comparative performance, the study contributes a domain-specific, theory-informed serious game design for mould-prevention education. The findings indicate that interactive gameplay provides an effective and engaging approach for supporting mould-prevention learning.

1 | Introduction

Indoor Air Quality (IAQ) is a critical determinant of human health and well-being, particularly within residential environments. Among the various contributors to poor IAQ, mould contamination is one of the most pervasive and harmful, thriving in damp and inadequately ventilated spaces (Heseltine and Rosen 2009). Exposure to mould has been linked to a wide range of adverse health effects, including respiratory problems, allergic reactions, and the exacerbation of asthma symptoms, especially among vulnerable populations such as children, the elderly, and individuals with pre-existing conditions (Hao et al. 2024; WHO 2019). These concerns are not confined to any one region; they represent a growing global public health issue.

Around the world, ageing housing stock, poor ventilation, and inadequate moisture control contribute to widespread mould contamination in residential buildings.

In many countries, particularly across Europe and North America, outdated construction practices and energy-inefficient homes have led to persistent dampness and poor air circulation. For example, a pan-European study reported that approximately 12% of households experience mould-related issues, with vulnerable populations such as low-income families and children disproportionately affected (WHO 2023). In the United States, the Centers for Disease Control and Prevention have acknowledged indoor mould as a significant health concern, especially in flood-prone regions where

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Lay Summary

- What is currently known about this topic?
 - Indoor mould harms health and housing quality worldwide.
 - Public education often relies on passive video instruction.
 - Serious games can improve engagement and learning.
 - Long-term retention in IAQ and mould prevention education is underexplored.
- What does this paper add?
 - Develops a theory-informed serious game for mould prevention.
 - Compares game-based and video learning through a between-subject experiment.
 - Shows stronger four-week knowledge retention with the game condition.
 - Finds higher motivation and lower task load in the game condition.
- Implications for practice and/or policy
 - Educators should consider integrating serious games into IAQ and mould prevention education.
 - Interactive environments may enhance applied learning in housing health.
 - Understanding learner motivation can guide effective game implementation.
 - Implementation strategies should include follow-up support for behaviour change.

sustained moisture creates ideal conditions for fungal growth. Similar challenges are also reported in parts of Asia, South America, and Oceania, where climatic factors, overcrowding, and limited public awareness further exacerbate the risks. Collectively, these patterns reflect the urgent need for scalable, effective educational interventions to address indoor mould exposure worldwide.

Recent research highlights that pollution levels indoors can exceed those found outdoors, even in densely populated urban areas (IQAir 2018; MANA, n.d.; Sanalife 2022). Kankaria et al. (2014) reported that the impact of indoor air pollution can be up to 10 times more severe than that of outdoor pollution. Given that individuals spend approximately 90% of their time indoors, the potential health risks associated with indoor pollutants are significantly magnified (Tran et al. 2020). According to the WHO (2023), “Each year, 3.2 million people die prematurely from illnesses attributable to household air pollution. Particulate matter and other pollutants in household air inflame the airways and lungs, impair immune response, and reduce the oxygen-carrying capacity of the blood.”

These global concerns are acutely relevant to New Zealand, where mould-related problems are particularly prevalent (Environmental Health Intelligence 2025). According to a 2015 BRANZ survey highlighted in Consumer (2023), more than half of rental homes in New Zealand had visible mould, often caused by persistent moisture issues that are difficult for tenants to control. Keall et al. (2012) also found that such conditions

were associated with increased rates of wheezing and asthma. Cold and damp housing environments contribute to higher seasonal mortality rates and increased incidences of cardiovascular and respiratory illnesses. In 2018, approximately 28,000 New Zealand homes were reported to be persistently damp and to have visible mould larger than A4 size (StatsNZ 2020). Thus, addressing mould-related issues in New Zealand housing is both urgent and necessary. A substantial body of research has established the link between poor IAQ and adverse health outcomes in mould-affected dwellings (Graham 2023; Lewis et al. 2023; Morawska et al. 2024; Nature Editorial 2023; Stokstad 2004).

Addressing these challenges requires not only technical solutions but also effective educational strategies to raise awareness and promote sustainable behavioural change (Freeman et al. 2014). While traditional methods (e.g., brochures and instructional videos) have been widely used to convey health messages, they often lack the interactivity and engagement needed to maintain attention, foster motivation, and support long-term knowledge retention (Mayer 2017).

Educating individuals about such issues is paramount due to their significant and far-reaching implications on public health and the environment (Marcotte 2017). If people become more aware of the importance of air pollution, it is more likely to prompt positive changes in both individual behaviour and public policies (Kelly and Fussell 2015). This increased awareness has the potential to drive actions to mitigate pollution, resulting in a cleaner environment and a healthier population (Arcury 1990; Wang et al. 2016). Many people are unaware of the invisible threats in the air we breathe, and raising awareness is crucial for informed decision-making and behaviour (Barbosa et al. 2017).

Serious games provide an alternative approach by transforming passive learning into an active and immersive experience (Checa and Bustillo 2020). These games simulate real-world scenarios, enabling learners to apply knowledge in meaningful and contextually relevant ways. An innovative and alternative approach gaining momentum is the incorporation of gamification into air quality education. Gamification transforms learning about air quality into an engaging and interactive experience by applying game elements and offering various features such as real-time data collection. Through gamified applications and platforms, individuals can participate in challenges, quizzes, and simulations that simulate real-world scenarios related to air quality (Stamatiadou et al. 2023).

The use of gamification has been explored in many fields. For example, it has been successfully applied to training in areas such as earthquake preparedness (Çoban and Göktaş 2023; Feng et al. 2021; Mirsoleymani et al. 2022), safety procedures (Kazar and Comu 2021; Lovreglio et al. 2021), construction site awareness (Lu et al. 2024; Tagliabue et al. 2020), hazard detection (Cavalcanti et al. 2021; Mohd et al. 2019; Ren et al. 2022), and risk management (Taillandier and Adam 2018), as well as broader topics in the built environment (Ilbeigi et al. 2024; Lai et al. 2020; Villagrasa et al. 2014).

Prior comparative research demonstrates that serious games typically produce small-to-moderate gains in learning ($g \approx 0.29-0.36$) and motivation ($g \approx 0.34-0.48$) relative to

conventional instruction (Sailer and Homner 2020; Wouters et al. 2013). In health and medical education, serious games and gamified approaches are often at least as effective as standard teaching, and in many cases more effective, although findings are not uniform across all outcomes and designs (Gentry et al. 2019). However, these studies have predominantly focused on disciplines such as medicine, nursing, and STEM education and have not directly addressed IAQ or residential mould education. Furthermore, much of the existing comparative research emphasizes immediate post-learning outcomes rather than long-term knowledge retention or real-world behavioural transfer, which are critical for sustained environmental health practices (Maheu-Cadotte et al. 2018).

A recent systematic literature review conducted by Baghaei Daemei, Lovreglio, et al. (2025) examining gamification in air quality education identified serious game applications in domains such as general air pollution awareness, environmental sustainability, and health education, but found minimal attention to residential mould prevention as a specific instructional target. This confirms that mould-prevention education remains an underexplored area within serious game-based environmental health interventions. This highlights a significant domain-specific gap: While air-quality gamification has been used to raise awareness (Campana and Dominguez 2021; Fernandes et al. 2023) and support asthma management (Kim et al. 2022; Thomson et al. 2017), no existing work supports actionable mould-prevention knowledge or real-world behavioural transfer in residential contexts.

As such, this study aims to address this gap by developing and evaluating the effectiveness of a serious game compared to video-based learning aimed at educating the general public on mould prevention techniques in residential settings. The evaluation focuses on key learning performance metrics, including knowledge acquisition and retention, cognitive task load, system usability, intrinsic motivation, and self-efficacy. This research contributes to the growing body of knowledge on educational strategies in the built environment. In doing so, this study expands the limited research on serious games for mould prevention and informs practical, scalable educational strategies for addressing poor indoor air quality in residential environments. Ultimately, it contributes to a healthier and more resilient built environment.

Many serious games are built on established instructional and motivational design frameworks, including LM-GM mapping (Arnab et al. 2015), the RETAIN model (Gunter et al. 2008), and the MDA framework (Hunicke et al. 2004). Meta-analyses also show that game-based learning outcomes are frequently linked to constructs from Self-Determination Theory, the ARCS model, and related theories (Krath et al. 2021; Landers 2014; Sailer and Homner 2020). At the same time, the degree of theoretical alignment across the broader field remains uneven, with many applications offering limited explanation of how specific mechanics connect to learning objectives or behavioural processes. Education in the built environment, including IAQ and mould prevention, presents an even larger gap: Very few studies integrate structured design models with the behavioural and perceptual demands of identifying mould risks and adopting effective

moisture-management habits. This gap establishes the need for a theory-informed approach tailored to mould-prevention education.

This study theorizes that mould-prevention education poses unique instructional demands that differ from other health and safety domains. Mould risk is shaped by micro-level household actions that directly modify the indoor environment, such as ventilation practices, moisture-generating activities, surface exposure, and material choices. These actions alter airflow, surface temperature, and humidity conditions, which require situated spatial reasoning rather than declarative recall. The game was therefore intentionally designed with interactive spatial environments that allow learners to test environmental modifications and observe their effects through immediate feedback. This alignment between instructional modality and domain-specific learning requirements represents a theoretical rationale underlying the study design.

2 | Materials and Methods

This study investigates the effectiveness of a serious game in enhancing knowledge related to mould prevention in residential buildings compared with video-based learning. The overall research workflow is illustrated in Figure 1. This study followed a structured multi-stage development and evaluation process (Figure 1). First, we defined the conceptual requirements of the intervention (Step 1) and collected relevant educational content on mould prevention in homes (Step 2). The materials were refined through interviews and in-home assessments to ensure practical relevance (Step 3), followed by prototyping of both the game and the video-based learning module (Step 4). Next, we developed the experimental design and questionnaires (Step 5), recruited participants (Step 6), and conducted the experiment and data collection (Step 7). Finally, collected data were analysed to assess the intervention's impact (Step 8). Each development step underwent iterative internal review and debugging, informing refinement across stages.

The subsections of this Section 2.1–2.5 reflect the core phases of the method. The initial phase involved the development of a serious game, detailed in Section 2.1. This was followed by implementing and testing the game-based learning, as outlined in Section 2.2. Both qualitative and quantitative data were collected from volunteer participants, as described in Section 2.3. The data analysis procedure and participant information are described in Sections 2.4 and 2.5, respectively. All participant responses were collected, encoded, and subjected to statistical analyses, which are presented in Section 3.

2.1 | Game Development

This study presents a serious game prototype designed to educate individuals on mould growth prevention in residential buildings. The game aims to engage users in identifying mould-prone areas, understanding the conditions conducive to mould formation, and applying practical strategies to prevent mould growth. The game was developed using Storyline 360 (www.articulate.com/360/storyline), which provides an

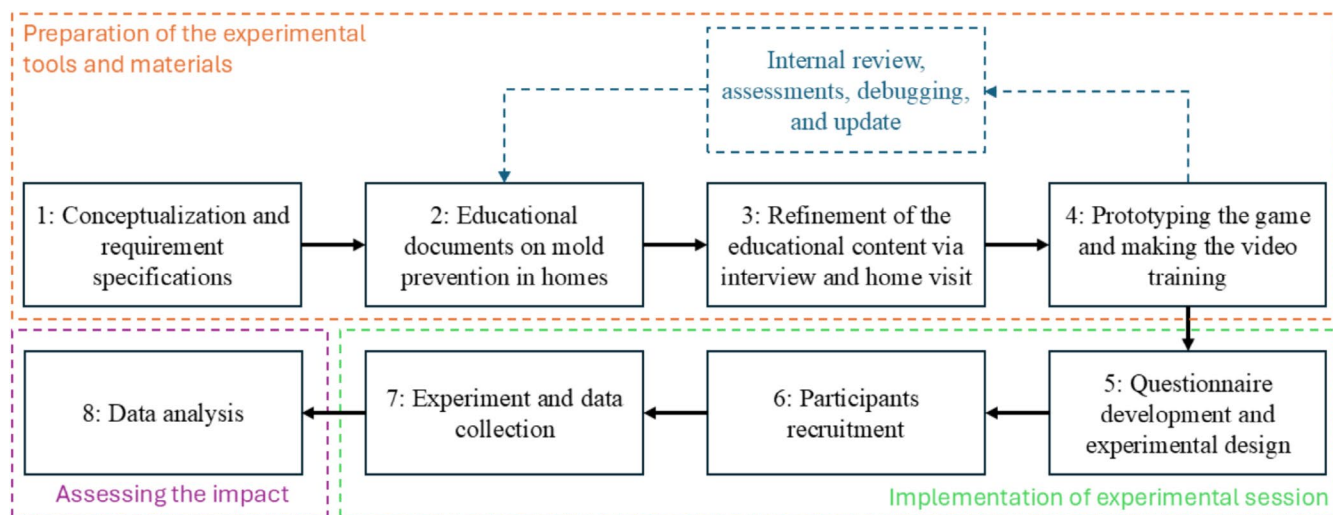


FIGURE 1 | Research process workflow.

easy-to-use design interface and supports the creation of interactive elements such as triggers, clickable areas, and dynamic feedback. It is designed to be accessible on various platforms, including PCs, laptops, tablets, and smartphones, ensuring that users from diverse backgrounds can engage with the content independently. The target audience for this serious game comprised the general public across New Zealand, including homeowners, renters, and individuals living in diverse housing conditions. This is supported by several studies reporting that more than half of New Zealand rental houses had visible mould (BRANZ 2015; Consumer 2023). The game was developed using New Zealand housing and climate conditions as an initial case-study context. The educational content can be substituted or expanded to suit other regions and housing typologies. This structure allows the intervention to be adapted for international use with minimal reconfiguration of the underlying system.

2.1.1 | Learning Outcomes

The game has four learning outcomes (LOs) designed based on Bloom's Taxonomy (Krathwohl 2002), focusing on three cognitive levels: remember, understand, and apply. This framework ensures a structured progression of learning, guiding players from basic knowledge acquisition to practical application in real-life scenarios. The LOs are presented as follows:

- Remember (LO1 and LO2): This module involves recalling facts and recognising key information. LO1 requires players to identify specific spots in the kitchen, bedroom, and bathroom where mould is likely to grow, reinforcing memory-based recognition of mould-prone areas. Similarly, LO2 focuses on recalling the essential elements of mould formation—temperature, humidity, spores, and nutrients—helping players establish foundational knowledge of mould growth conditions.
- Understand (LO3): This module emphasizes comprehension and the ability to explain concepts. LO3 requires players to understand how specific environmental conditions, such as temperature and humidity, contribute to mould

growth. This goes beyond memorization by enabling players to connect different factors and predict when and where mould is likely to develop.

- Apply (LO4): This module involves using acquired knowledge in real-world contexts. LO4 focuses on applying strategies to prevent mould growth in residential buildings. This requires players to take what they have learned about mould-prone areas, essential growth factors, and environmental conditions and translate that knowledge into actionable steps for maintaining a healthier indoor environment.

The learning outcomes and educational content were developed based on official public sources, including relevant governmental regulations, standards, building codes, and international publications (Baghaei Daemei, Feng, and Paes 2025). This provided evidence-based knowledge rather than general assumptions. The game had four modules to accommodate the four learning outcomes (Figure 2). Players completed the entire learning process by playing the game from Module 1 to Module 4.

2.1.2 | Game Mechanics

The Octalysis Gamification Design Theory principles (Chou 2015) were applied in the development of the game to enhance engagement and motivation. This theory proposes game mechanics aligned with intrinsic and extrinsic motivators, which can engage and motivate players while delivering educational content. Chou (2015, 31) provides eight core drives (CDs) and associated game mechanics to engage and motivate players in different ways. Table 1 presents the selected game mechanics for the serious game.

2.1.3 | Game Storyline

In this game, players explored a typical house in New Zealand, focusing on three key rooms: the kitchen, bedroom, and bathroom. The player took on the role of a new resident who needed to prevent mould growth in these rooms. The game began with

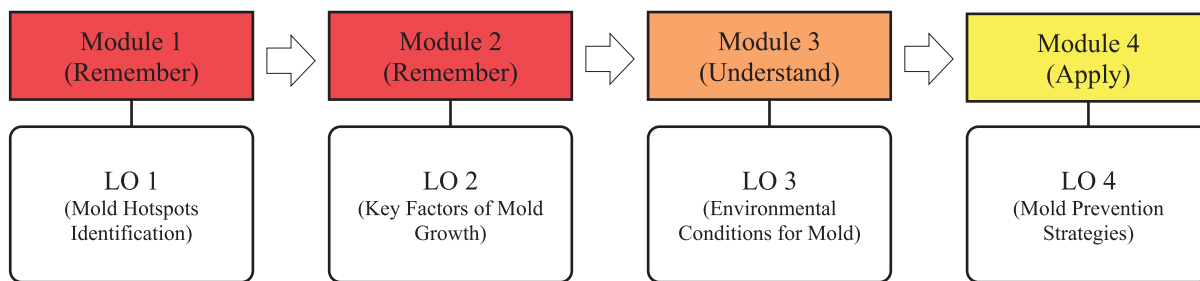


FIGURE 2 | The learning outcomes and game modules.

an introductory briefing that explained the importance of mould prevention and the game's educational objectives. The player was welcomed into a virtual house and presented with common mould issues typically found in residential buildings. As shown in Figure 3, players progressed through the game from Module 1 to Module 4 in a linear manner, where they had to complete the previous module to unlock the next one.

The player was guided by Mr. Grumpy Moldwell, a virtual assistant who provided tips and instructions throughout the game. His guidance was delivered through textual prompts and audio instructions, which were given before each module to ensure clarity and ease of understanding. The story unfolded interactively, with the player making decisions and seeing the immediate impact of their actions on the indoor environment. This structure ensured that the player engaged with the content in a realistic and informative way, building skills that could be applied to real-life scenarios to prevent mould growth in their homes.

2.1.4 | Verification and Refinement

To ensure the game aligned with the learning objectives and accurately reflected real-world conditions, a verification and refinement phase was conducted, consisting of expert interviews and home-visit observations. These interviews assessed the relevance and accuracy of the educational content, game scenarios, and mould prevention strategies. Experts provided feedback on the learning outcomes and suggested improvements to scenario realism and content clarity. Following that, six residential homes in Auckland were visited to directly observe mould-prone conditions and validate the environmental contexts represented in the game. Visual data collected was cross-referenced with expert input to reinforce the validity of the scenarios. The final version of the game was established based on the interview and home visit findings. Further methodological and analytical details about this phase are provided in the published study (Baghaei Daemei, Feng, and Paes 2025).

Experts were invited via email to participate in an online interview, with scheduling coordinated through Doodle. Twelve of more than sixty contacted IAQ professionals agreed to take part. Interviews were conducted on Microsoft Teams and lasted about 40 min. Sessions were recorded and transcribed through Teams, and the qualitative data were coded thematically using NVivo. Participants received an information sheet and provided signed consent before the interviews.

Table 2 summarises the demographic characteristics of the interviewees.

2.2 | Experimental Design

This study adopted a between-subjects experimental design, where each participant was exposed to only one of the two learning methods (game or video). Figure 4 illustrates the experimental design framework, including the research instruments and variables. This approach was chosen to prevent learning effects that could occur in a within-subjects design, where participants would experience both conditions. In such cases, performance in the second condition could be influenced by prior exposure to the first, thereby biasing the results (Paes et al. 2024).

Participants were randomly assigned to one of the two groups, with one using the serious game as the experimental group and the other as the control group using video learning. Both methods comprised identical learning outcomes and educational content. The same images used in the serious game were incorporated into the video to maintain visual consistency (Figure 5). The video was structured with four main sections: (1) common mould growth spots, (2) key elements required for mould development, (3) optimal temperature and humidity ranges to prevent mould growth, and (4) effective strategies for mould prevention. The narration in the video used the same voice as the one featured in the game, maintaining uniformity in tone and delivery. Participants were permitted to pause the video at any time; however, they were not allowed to take notes, and the rewind function was restricted to only one slide back.

Video-based learning was selected as the comparison condition because it represents one of the most commonly used digital formats for public-health communication (Chatterjee et al. 2021). Unlike brochures or flyers, videos can deliver structured explanations, visuals, and demonstrations that closely match the content density and pacing of the game (Galmarini et al. 2024; Morgado et al. 2024). This makes video a more appropriate benchmark for isolating the role of interactivity, since both modalities present the same information but differ in the level of learner engagement.

Each group went through a pretest, intervention, posttest, and retention test. The retention test occurred 4 weeks after the posttest, aligning with previous similar studies (Domgue K

TABLE 1 | The selected game mechanics incorporated into the game.

Core drives (CDs)	Mechanics	In-game application	Explanation/usage
CD 1: Meaning	Narrative Higher Meaning	Story-driven progression through house rooms Learners believe their actions affect real health	Narrative refers to the storyline and context that immerse players in the learning experience. It integrates characters, scenarios, and challenges that provide a real-world framework for players to explore through a compelling story. It provides players with a sense of purpose beyond the game itself. Players are motivated not just by the game's rewards, but by the belief that their actions contribute to a greater cause or have real-world significance.
CD 2: Accomplishment	Points Progress Bar Quest Lists	Player gains points for correct answers Shows completion of each module Tasks guide exploration	Points are extrinsic rewards that recognise players' actions and achievements. The progress bar visually represents how far the player has come in completing a task or mission. Quest lists outline tasks or challenges that guide the player's journey.
CD 3: Empowerment	Step-by-Step Tutorial LevelUp Symphony Milestone Unlock	Explanation before each module Unlocking next module After completing a task (e.g., identifying all condensation hotspots), the next module or tool becomes available	The tutorial breaks down tasks and teaches the player how to succeed in the game. Whenever you level up, you acquire a new set of skills. It represents a key achievement or significant event in the game that rewards the player with new content and levels. It marks the completion of a specific set of tasks.
CD 4: Ownership	Instant Feedback Avatar	Immediate reinforcement Personalised the gameplay	The immediate responses players receive based on their actions or decisions in the game.
CD 5: Social Influence	Mentorship	Virtual assistant guidance	A customizable digital representation of the player within the game. It refers to a guidance system where an experienced character (a virtual character) provides the player with advice, support, and knowledge.
CD 7: Unpredictability	Visual Storytelling	When a player completes a module, a brief animation and confirmation cue appear	This mechanic uses images, animations, and design elements to convey the game's narrative and themes. Rather than relying on text or dialogue, it communicates key messages, emotions, and ideas through art style, character design, environments, and visual cues.
CD 8: Avoidance	Progress Loss	Penalty for wrong responses	It refers to the mechanic where players lose some in-game points after failing the task or challenge.



FIGURE 3 | Screenshots of module 4 and its activities.

et al. 2025; Paes et al. 2024). Participants were provided with a laptop in the lab to complete the pretest, learning, and posttest. Each session took around 30 min for the game group and 20 min for the video group. Participants completed the online retention test 4 weeks later using their own device.

The video used in the comparison condition presented the same educational content as the game, refined into a continuous 5-min narrated explanation of mould-prevention concepts without interactive elements. Participants completed the pre-test and post-test questionnaires in approximately 15 min, and

TABLE 2 | Interviewees' demographics.

Category	Subcategory	Percentage (%)
Age	25–34 years	9.1 (<i>N</i> = 1)
	35–44 years	36.4 (<i>N</i> = 4)
	45–54 years	27.3 (<i>N</i> = 4)
	55–64 years	27.3 (<i>N</i> = 3)
Gender	Female	36.4 (<i>N</i> = 5)
	Male	63.6 (<i>N</i> = 7)
Education	Associate degrees	18.2 (<i>N</i> = 1)
	Bachelor's degrees	18.2 (<i>N</i> = 3)
	Master's degrees	27.3 (<i>N</i> = 4)
	Doctoral	36.4 (<i>N</i> = 4)
Profession	Advisor	8.33 (<i>N</i> = 1)
	Building Scientist	16.67 (<i>N</i> = 2)
	Senior Lecturer	8.33 (<i>N</i> = 1)
	Housing Assessor	8.33 (<i>N</i> = 1)
	Sustainability Specialist	16.67 (<i>N</i> = 2)
	Research Scientist	16.67 (<i>N</i> = 2)
	Architect	8.33 (<i>N</i> = 1)
Experience	Senior Technician	8.33 (<i>N</i> = 1)
	1–5 years	9.1 (<i>N</i> = 1)
	6–10 years	18.2 (<i>N</i> = 2)
	11–15 years	27.3 (<i>N</i> = 2)
	Over 16 years	45.5 (<i>N</i> = 7)

Source: Authors' own work.

the retention questionnaire required about 5 min. To link pre-, post-, and retention data, each participant was assigned a unique anonymous identifier. Email addresses were used solely to distribute the retention questionnaire and were stored separately from response data. No personal or demographic information was collected, and all procedures adhered to institutional ethical approval and data-protection requirements. The pre-test and post-test knowledge assessments consisted of the same set of questions, presented in the same order and format, to allow for direct comparison of learning gains.

The independent variable in this study was the intervention method, with the game and video as the two conditions. The dependent variables included knowledge measured with an open-ended questionnaire, self-efficacy measured using the General Self-Efficacy (GSE), intrinsic motivation measured with the Intrinsic Motivation Inventory (IMI), user experience measured through the NASA Task Load Index (TLX) and the NASA Modified System Usability Scale (NMSUS), and behavioural change assessed through a questionnaire on implemented mould prevention strategies. As demonstrated in Figure 8, knowledge and self-efficacy were measured in the pretest, posttest, and retention test; motivation and user experience were measured in

the posttest; and behavioural change was measured in the retention test. In addition, participant demographic information was collected in the pretest.

2.3 | Data Collection Instruments

This section outlines the data collection instruments used in the experiment. The complete questionnaires used for the pretest, posttest, and retention test are provided in Appendix A.

2.3.1 | Demographics

This part gathered information including age, gender, type of residential housing, and frequency of playing video games. This data was used to contextualize participant characteristics and ensure consistency among participant profiles between the two groups.

2.3.2 | Knowledge

An open-ended questionnaire was used to assess participants' knowledge to identify mould-prone areas, understand the essential conditions for mould growth, recognise temperature and humidity ranges to prevent mould growth, and apply prevention strategies. Participants' responses were manually scored. For the first module, correct answers included four spots in the kitchen, five spots in the bedroom, and six spots in the bathroom. Participants obtained 1 score for each correct spot mentioned in their responses. For the second module, correct answers included four key elements: moisture, cold surface, nutrients, and spores. Participants obtained 1 score for each correct item mentioned in their responses. For the third module, correct answers included two items, including temperature (20°C–24°C) and humidity (40%–60%). For the fourth module, the correct answers included nine mould prevention strategies. As a result, a participant could score between 0 and 30 points in total for the four modules. The same scoring method was applied for the pre-test, post-test, and retention test.

2.3.3 | Intrinsic Motivation

In this study, a customised version of the Intrinsic Motivation Inventory (IMI) (Choi et al. 2010) was used to assess the intrinsic motivation of participants during their learning process. IMI is grounded in the Self-Determination Theory (SDT)—which emphasises the importance of autonomy, competence, and relatedness in fostering motivation and engagement—and is commonly used to evaluate how enjoyable, interesting, and engaging participants found the material, as well as their level of focus, relaxation, and enjoyment during the learning experience (Ryan and Deci 2020). Based on the standard IMI framework developed by Deci and Ryan (2013), three subscales were selected for their relevance to the study context: interest/enjoyment, perceived competence, and pressure/tension. Each subscale featured three items. Each item was rated using a 7-point Likert-type scale, ranging from 1

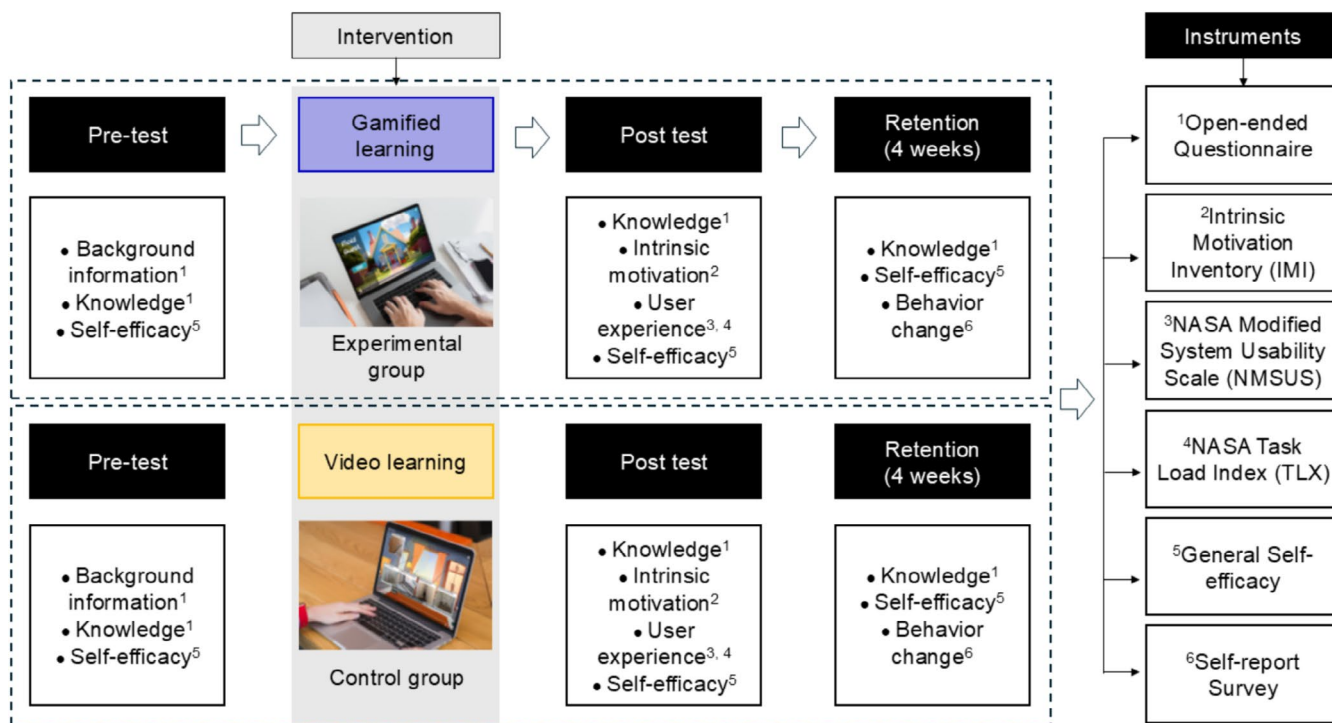


FIGURE 4 | The experimental design framework.

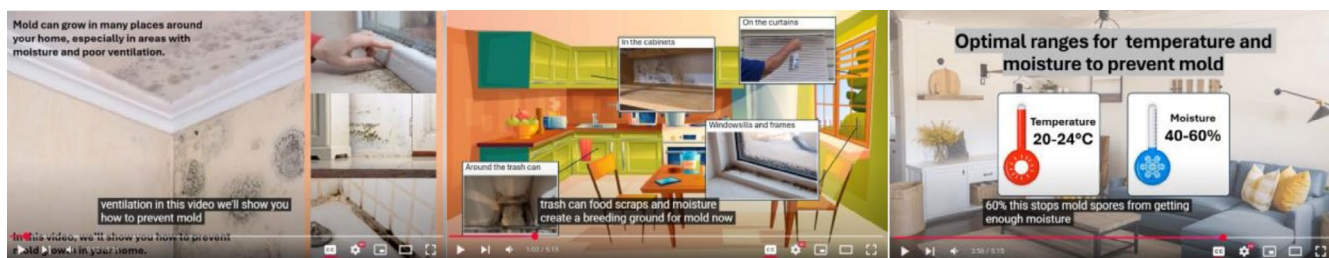


FIGURE 5 | Screenshots of the video.

(strongly disagree) to 7 (strongly agree). For each participant, scores for each subscale were calculated by averaging the scores of the relevant items. Higher scores indicated higher levels of intrinsic motivation.

2.3.4 | System Usability Scale

The NASA Modified System Usability Scale (NMSUS) (NASA 2023) was employed to evaluate the usability of the learning tools (game or video). This scale provides insights into how user-friendly the learning tools were and whether technical support was needed for efficient use. Each item was rated using a 7-point Likert-type scale, ranging from 1 (strongly disagree) to 7 (strongly agree). For each participant, their NMSUS score was averaged from eight items. Higher scores indicated higher perceived usability levels.

2.3.5 | Task Load Index

The NASA Task Load Index (TLX) (Hart 2006) was used to measure the perceived task load during the learning experience

for both game and video groups. The tool is particularly popular in human-computer interaction, usability research, aviation, healthcare, and education contexts (Kosch et al. 2023). The NASA TLX consists of six dimensions of subjective task load, including: mental demand, physical demand, temporal demand, performance, effort, and frustration level. Each dimension featured one item and was rated by participants on a Likert-type scale ranging from 0 to 20, where 0 indicated very low and 20 indicated very high task load.

2.3.6 | Self-Efficacy

The General Self-Efficacy Scale (GSE) (Luszczynska et al. 2005) was used to evaluate participants' self-perceived capability to handle challenges related to mould prevention, ranging from general confidence to specific actions, such as identifying solutions and applying preventive strategies. In this study, the GSE was administered using a 7-point Likert-type scale, with response options ranging from 1 (completely false) to 7 (completely true). The scale consists of five items. The overall self-efficacy score for each participant was computed by averaging the scores of all items. Higher total scores indicate greater perceived self-efficacy.

2.3.7 | Behavioural Change

The behavioural change questionnaire assessed participants' self-reported changes in behaviour following the intervention after 4 weeks. It measured the frequency of mould checks, the implementation of prevention strategies, and any noticeable changes in behaviour after the learning experience. It consisted of five items with a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). For each participant, the average was calculated from all five items. Higher scores indicated a greater degree of perceived behavioural change observed by participants.

2.4 | Data Analysis

Inferential statistical analysis was conducted to assess the effectiveness of the two learning interventions—serious game and video—across multiple measurements. This analysis aimed to determine whether the observed differences between the groups were statistically significant.

First, the dataset was screened for completeness to remove invalid or incomplete responses. Within the post-test questionnaire, an attention check question was included: "I will answer this questionnaire seriously, so for this question I will choose DISAGREE". Participants who selected any response other than "Disagree" were considered to have failed the attention check, resulting in the exclusion of their data. Consequently, 10 out of the 120 responses were eliminated ($n=4$ from game learning and $n=6$ participants from video learning) from the analysis.

Second, the normality of each outcome variable was assessed using the Kolmogorov–Smirnov test (Razali and Wah 2011), supported by visual inspections such as histograms and plots. The test indicated that the responses for each measurement were not normally distributed. Therefore, Mann–Whitney U tests were used to test the significance between groups.

Third, within-group comparisons (e.g., pretest vs. posttest, and posttest vs. retention) were conducted using the Wilcoxon signed-rank test when data violated normality assumptions. This non-parametric approach was chosen to appropriately assess changes over time within each intervention group for paired samples.

Lastly, for each outcome measure, effect sizes were calculated to evaluate the magnitude of observed differences. For between-group comparisons, Cohen's d was determined by calculating the mean difference between the two groups and then dividing the result by the pooled standard deviation: Cohen's $d = (M_2 - M_1) / SD_{\text{pooled}}$, where $SD_{\text{pooled}} = \sqrt{((SD_1^2 + SD_2^2) / 2)}$ (Cohen 2013). For within-group comparisons, Cohen's d was determined by dividing the mean of the differences by the standard deviation of the difference from paired samples: Cohen's $d = M_{\text{Difference}} / SD_{\text{Difference}}$ (Dankel and Loenneke 2021).

2.5 | Participants and Experiment Session

This study employed a non-probabilistic convenience sampling strategy, with a total of 120 participants (60 per group) recruited from the general public. Efforts were made to ensure diversity

in age, household type, and socio-demographic background. A power analysis with a large effect size ($d=0.8$), a significance level of $\alpha=0.05$, a statistical power of $1-\beta=0.80$, and a two-tailed test to detect the mean difference between two independent groups was conducted using G*Power 3.1.9.7, indicating 26 participants as the required sample size for each group. Given that this study involved a four-week retention test, where sample sizes might drop for the retention test, a larger sample size of 60 participants for each group was selected. This sample size aligns with those reported in related studies in the field, such as Tarng et al. (2016) with $n=56$, Zhang and Robb (2021) with $n=60$, Paes et al. (2024) with $n=50$, Feng et al. (2024) with $n=40$, and Domgue K et al. (2025) with $n=60$. As mentioned in Section 2.4, 10 participants failed the attention check, resulting in 56 participants valid for the game group and 54 participants for the video group. Also, the number of participants completing the retention test dropped to 36 for the game group and 33 for the video group.

Participants were recruited using flyers and word of mouth. Prior to participation, participants were informed about the study through an information sheet and were required to sign a consent form. As a token of appreciation, each participant received a NZD 10 supermarket voucher upon completion. This experiment received a Low-Risk Notification (4000030296) from the Massey University Human Ethics Committee. Figure 6 depicts participants taking part in the experimental session, including both the game and video-based learning groups.

Participants were required to meet basic inclusion criteria: they had to be 18 years of age or older and able to read and understand English sufficiently to complete the study materials. No additional exclusion criteria were applied, and prior gaming experience was not required for participation. All participants completed the experiment using laptop computers provided by the research team. A detailed breakdown of participant demographics, including gender, housing type, and video game frequency, is provided in Table 3. The demographic distribution included a higher proportion of women than men across both groups. Participants represented a variety of living situations, with the most common housing types being standalone houses, followed by townhouses and apartments or flats. In terms of video game familiarity, most participants reported playing video games occasionally, with a smaller proportion playing frequently or daily. Notably, a considerable number of participants indicated that they rarely or never engage with video games, suggesting varying levels of prior exposure to digital gaming environments.

3 | Results

This section describes the findings from the experiment conducted to evaluate the effectiveness of game learning in comparison to traditional video learning. The results are organised around key outcome variables, including knowledge acquisition and retention (Section 3.1), intrinsic motivation (Section 3.2), system usability (Section 3.3), task load (Section 3.4), general self-efficacy (Section 3.5), and behavioural change (Section 3.6).



FIGURE 6 | Participants engaging in game (left) and video learning (right) sessions during the experiment.

TABLE 3 | Sample demographics.

Parameter	Sample (n = 110)			
	Game group (n = 56)		Video group (n = 54)	
	#	%	#	%
Gender				
Man	23	41%	23	43%
Woman	33	59%	31	57%
Type of house				
Apartment/flat	14	25%	14	26%
Standalone house	27	48%	22	41%
Townhouse	15	27%	18	33%
Frequency of playing video games				
Never	11	20%	15	28%
A few times a year	16	28%	19	35%
A few times a month	14	25%	16	30%
A few times a week	9	16%	3	5%
Everyday	6	11%	1	2%

3.1 | Knowledge Acquisition and Retention

The knowledge scores obtained by participants in the game-based and video-based learning groups were analysed at three stages: before learning experience (Pre), immediately after learning experience (Post), and 4 weeks after learning experience (Ret). Figure 7 displays these scores using box plots. The data reveal a statistically significant increase in knowledge from Pre to Post for both the game-based and video-based groups. However, when comparing Post to Ret scores, a statistically significant decline in knowledge was observed only in the video-based group. The game-based group did not show a significant decline over the same period, indicating better knowledge retention (Table 4). Regarding group comparisons, no significant differences were found between the game and video-based learning groups at Pre or Post, suggesting

comparable learning outcomes immediately after the intervention (Post). However, 4 weeks later (Ret), the game-based group outperformed the video-based group in knowledge retention, with a statistically significant difference, reflecting a medium-to-large effect size in favour of game-based learning (Table 5).

3.2 | Analysis of Intrinsic Motivation

This section presents the analysis of intrinsic motivation scores collected from participants in both the game-based and video-based learning groups. Intrinsic motivation was assessed immediately after the learning intervention (Post) to explore differences between the two approaches. Figure 8 illustrates the average scores across three subscales, Interest/Enjoyment, Perceived Competence, and Pressure/Tension, using box plots. The analysis revealed a statistically significant difference in intrinsic motivation in favour of the game-based learning group. Participants who engaged in the game-based learning reported significantly higher levels of Interest/Enjoyment, with a medium effect size. Similarly, the game-based group scored significantly higher in Perceived Competence and Pressure/Tension, indicating reduced stress or anxiety compared to the video-based group. Although the effect sizes ranged from small to medium, the findings suggest that game-based learning had a meaningful positive impact on learners' intrinsic motivation across multiple dimensions when compared to traditional video-based learning (Table 6).

3.3 | Analysis of Perceived System Usability (NMSUS)

This section analyzes perceived system usability scores from participants in the game-based and video-based learning groups. Usability was measured immediately after the learning session (Post) to determine whether the instructional method influenced user perceptions of system usability. The average scores are illustrated in Figure 9 using a box plot. The analysis revealed a statistically significant difference in perceived system usability between the two groups. Participants in the game-based learning group reported higher usability scores compared to those in the video-based group. The test confirmed that this difference was statistically significant. Cohen's *d* indicates a medium effect, implying that the game-based

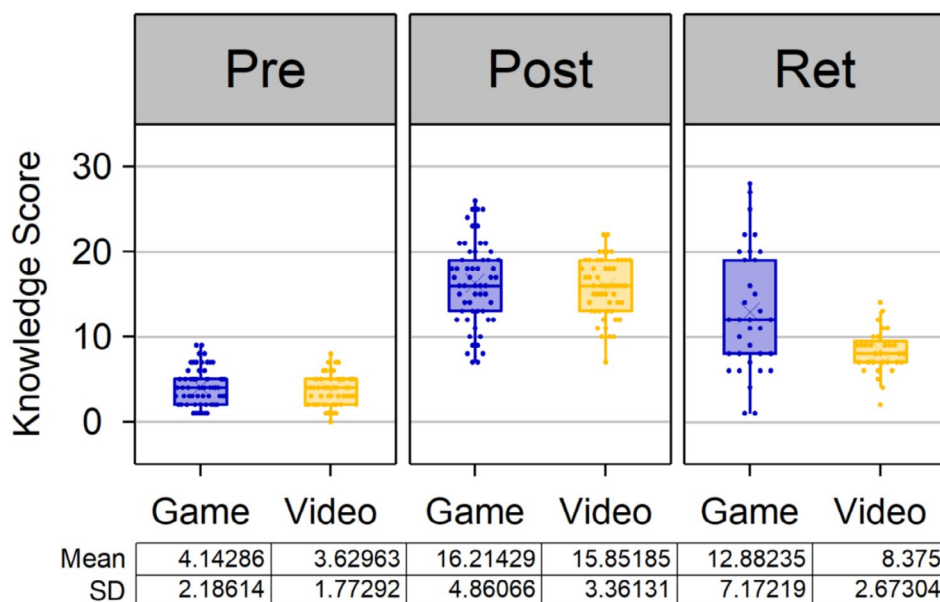


FIGURE 7 | Participants' knowledge scores before the learning (Pre), after the learning (Post), and after 4 weeks (Ret) in the game and video learning conditions.

TABLE 4 | Comparison of the knowledge scores before the learning (Pre), after the learning (Post), and after 4 weeks (Ret) for the game and video-based learning conditions.

Metric	Pre versus post		Post versus ret	
	Game	Video	Game	Video
Z	-6.514	-6.400	-0.883	-4.868
p	<0.001	<0.001	0.377	<0.001
d	2.742	3.883	0.158	4.146

TABLE 5 | Comparison between knowledge scores of the game and video-based learning conditions for the knowledge assessment done before the learning (Pre), after the learning (Post), and after 4 weeks (Ret).

Game versus video	Pre	Post	Ret
U	1337.5	1462.0	341.0
Z	-1.056	-0.300	-2.614
p	0.291	0.764	0.009
d	0.257	0.086	0.832

learning environment was perceived as notably more usable and user-friendly than the video-based alternative (Table 7).

3.4 | Analysis of Task Load (TLX)

This section evaluates the task load experienced by participants in the game-based and video-based learning groups, measured immediately after the learning intervention (Post). The analysis aims to assess whether the type of instructional method influenced participants' perceived task load. The average task load scores across the six NASA-TLX subscales are presented in Figure 10 using box

plots. The analysis revealed that participants in the game-based learning group reported significantly lower task load compared to those in the video-based group. These results indicate small to moderate effect sizes, suggesting that the game-based environment imposed less mental strain and time-related pressure on learners (Table 8).

3.5 | Analysis of Self-Efficacy (GSE)

This section analyzes self-efficacy scores reported by participants in both the game-based and video-based learning groups at three stages: before learning experience (Pre), immediately after learning experience (Post), and 4 weeks post-learning (Ret). These scores are illustrated in Figure 11 using box plots. The analysis showed a statistically significant increase in self-efficacy from Pre to Post in both groups. These results indicate large effect sizes, confirming that both methods were effective in improving participants' self-efficacy immediately after the learning intervention. When comparing Post to Ret scores, a statistically significant decline in self-efficacy was observed only in the video-based group, reflecting a moderate drop in perceived self-efficacy over time (Table 9). In contrast, the game-based group maintained its self-efficacy scores, showing no significant decrease. The analysis also revealed no statistically significant differences between the game and video-based learning groups at either Pre or Post, indicating similar baseline and immediate outcomes. However, a trend toward significance was noted at the Ret stage, suggesting that the game-based learning group may have been more effective in sustaining self-efficacy gains over the longer term (Table 10).

3.6 | Analysis of Behavioural Change

This section examines behavioural change scores reported by participants in the game-based and video-based learning

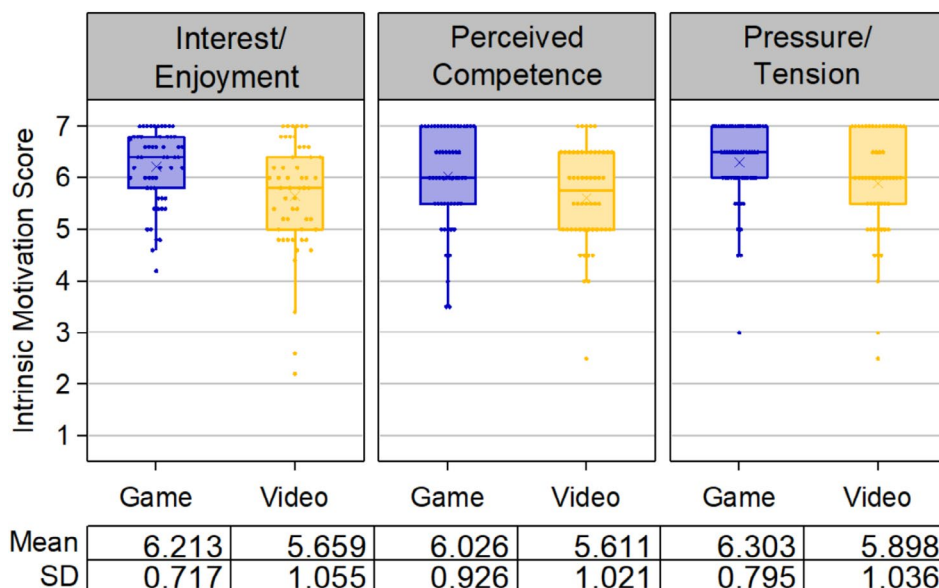


FIGURE 8 | Participants' intrinsic motivation scores after the learning (Post) in the game and video-based learning conditions.

TABLE 6 | The results of the Mann–Whitney U test for game versus video-based learning conditions for intrinsic motivation after the learning (Post).

Game versus video	Interest/enjoyment	Perceived competence	Pressure/tension
<i>U</i>	1024.0	1130.0	1153.0
<i>Z</i>	−2.929	−2.318	−2.206
<i>p</i>	0.003	0.020	0.027
<i>d</i>	0.614	0.426	0.438

TABLE 7 | The results of the Mann–Whitney U test for game versus video-based learning conditions for system usability after the learning (Post).

Game versus video	Value
<i>U</i>	950.0
<i>Z</i>	−3.370
<i>p</i>	<0.001
<i>d</i>	0.599

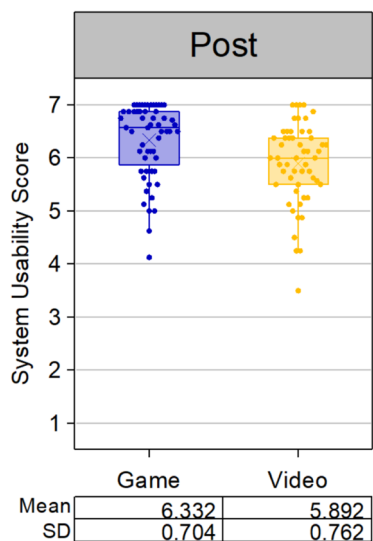


FIGURE 9 | Participants' system usability scores after the learning (Post) in the game and video-based learning conditions.

groups, measured 4 weeks after the learning intervention (Ret). The objective was to determine whether the type of instructional method influenced sustained behavioural change

over time. The results are presented in Figure 12 using box plots. The analysis revealed no statistically significant difference in behavioural change between the two groups after 4 weeks. Although the game-based learning group reported slightly higher behavioural change scores than the video-based learning group, the difference was not statistically significant. The effect size was very small, indicating minimal practical significance. These findings suggest that both instructional methods had a similar impact on participants' ability to implement and sustain behavioural changes 1 month after the learning experience. Neither method demonstrated a clear advantage in promoting long-term behavioural transformation (Table 11).

4 | Discussion

This study aimed to develop and evaluate the effectiveness of a serious game compared to video-based learning aimed at educating the general public on mould prevention techniques in residential settings. The evaluation focused on key learning performance metrics, including knowledge, self-efficacy, intrinsic motivation, system usability, task load, and behavioural change. A controlled between-subjects experiment was conducted to assess the learning and behavioural outcomes of both learning modalities.

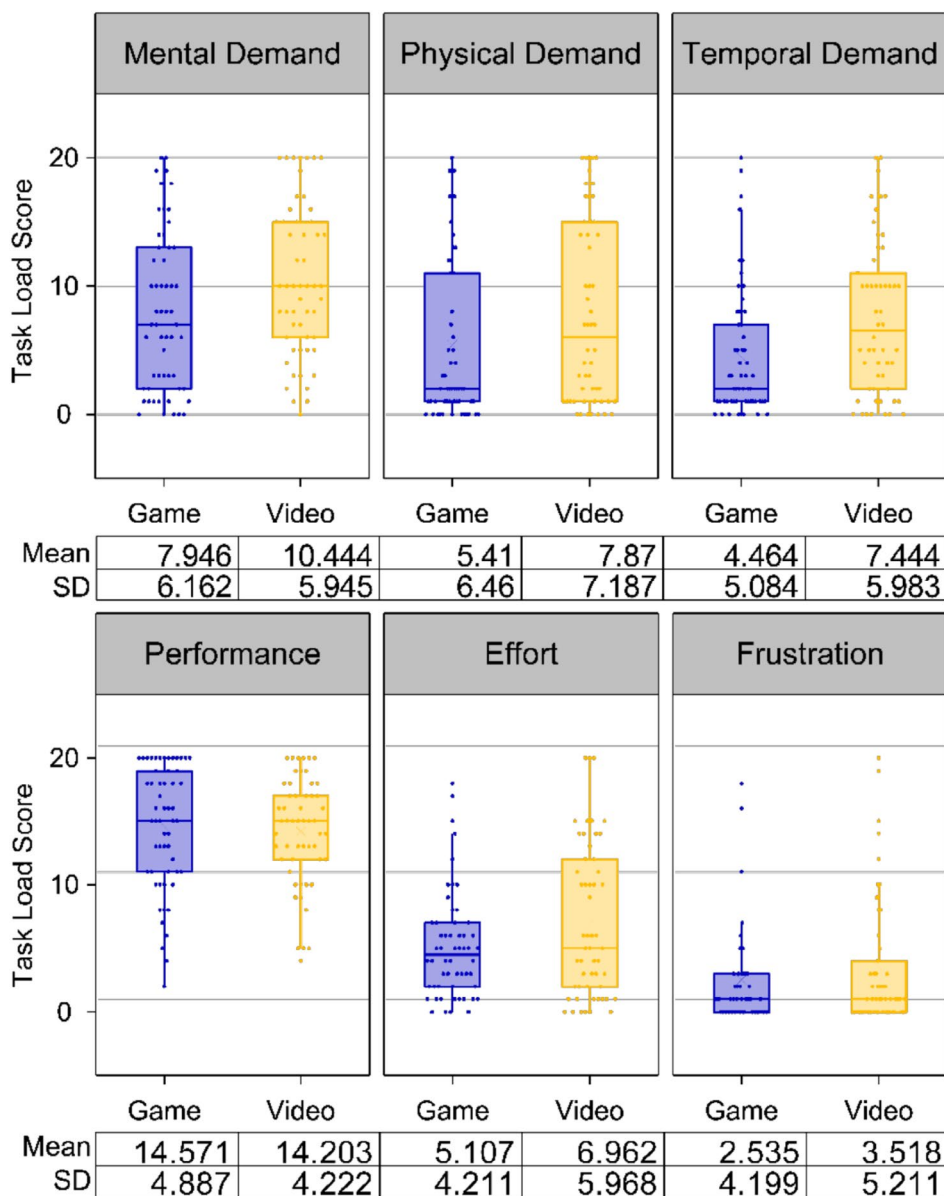


FIGURE 10 | Participants' task load scores after the learning (Post) in the game and video-based learning conditions.

TABLE 8 | The results of the Mann–Whitney U test for game versus video-based learning for task load after the learning (Post).

Game versus video	Mental demand	Physical demand	Temporal demand	Performance	Effort	Frustration
<i>U</i>	1145.5	1188.5	1063.0	1391.5	1325.5	1387.5
<i>Z</i>	-2.197	-1.947	-2.7	-0.724	-1.119	-0.769
<i>p</i>	0.028	0.051	0.007	0.469	0.263	0.442
<i>d</i>	0.412	0.359	0.536	0.080	0.359	0.207

Both the game-based and video-based learning conditions resulted in significant improvements in knowledge immediately after the learning experience (Post), with large effect sizes for both groups. However, only the game-based learning group maintained their knowledge after 4 weeks (Ret), showing no significant decline, while the video-based learning group experienced a significant decrease in knowledge. Notably, the game-based learning group outperformed the video group in

knowledge retention, with a statistically significant difference and a medium-to-large effect size. These findings are consistent with previous literature indicating that serious games can effectively support knowledge acquisition and improve long-term knowledge retention. For example, Sitzmann (2011) conducted a meta-analysis of 65 studies involving over 6000 participants and found that trainees taught with simulation games demonstrated 11% higher declarative knowledge and 9% greater retention

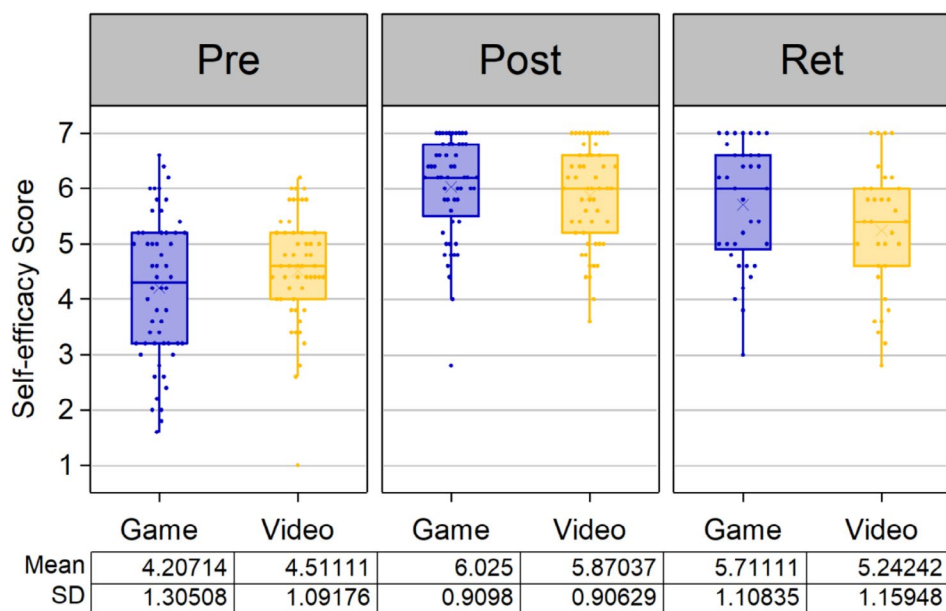


FIGURE 11 | Participants' self-efficacy scores before the learning (Pre), after the learning (Post), and after 4 weeks (Ret) in the game and video learning conditions.

TABLE 9 | Comparison of the self-efficacy score before the learning (Pre), after the learning (Post), and after 4 weeks (Ret) for the game and video-based learning conditions.

Metric	Pre versus post		Post versus ret	
	Game	Video	Game	Video
Z	-6.043	-5.562	-0.861	-2.306
p	<0.001	<0.001	0.389	0.021
d	1.251	0.965	0.111	0.480

TABLE 10 | Comparison between self-efficacy score of the game and video-based learning conditions for the knowledge assessment done before the learning (Pre), after the learning (Post), and after 4 weeks (Ret).

Game versus video	Pre	Post	Ret
U	1297.0	1350.0	456.5
Z	-1.288	-0.974	-1.658
p	0.198	0.330	0.097
d	0.252	0.170	0.413

compared to those receiving traditional instruction. Similarly, Wouters et al. (2013), in a meta-analysis covering 77 studies, reported that serious games were significantly more effective than conventional instructional methods in promoting both learning and retention. They further noted that the effectiveness of serious games was enhanced when games were used in combination with other instructional strategies, involved multiple sessions, and encouraged collaborative learning. More recent empirical studies have consistently demonstrated the superiority of serious games over traditional and video-based instructional methods in enhancing knowledge acquisition and retention.

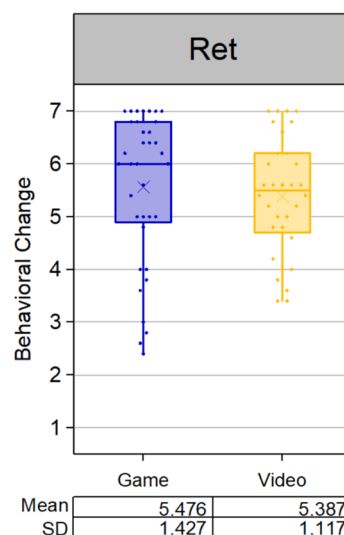


FIGURE 12 | Participants' behavioural change scores after 4 weeks of learning (Ret) in the game and video-based learning conditions.

TABLE 11 | Comparison between behavioural change scores of the game and video-based learning conditions for the behavioural change assessment done after 4 weeks (Ret).

Game versus video	Value
U	492.5
Z	-0.663
p	0.507
d	0.069

For instance, Hu et al. (2021) developed a serious game aimed at training undergraduate medical students in neonatal resuscitation. Their randomised controlled trial revealed that students

who engaged with the game exhibited significantly higher long-term knowledge retention compared to those who underwent traditional training methods. Additionally, Chen (2025) explored the impact of low-tech serious games in higher education settings. The study concluded that students who engaged in serious game-based learning retained more information than those who attended traditional lecture-based classes.

In this study, the game-based learning group reported significantly higher intrinsic motivation scores than the video-based learning group. This difference, with small to medium effect sizes, suggests that the game better satisfied participants' psychological needs for autonomy, competence, and low anxiety, critical components of sustained learning motivation according to the Self-Determination Theory. This aligns with prior research that identifies gamification elements as strong drivers of intrinsic motivation. For instance, a study by Söbke et al. (2020) compared serious gaming and traditional learning methods and found that serious gaming led to higher intrinsic motivation along with lower mental load compared to traditional methods. Additionally, Sailer et al. (2017) conducted an experimental study examining the effects of gamification on intrinsic motivation and performance. The study found that gamified learning environments, which included elements like narrative, avatars, challenge, feedback, and rewards, significantly increased self-reported intrinsic motivation among participants.

System usability scores indicated that the serious game was perceived as significantly more user-friendly than the video-based method, with a medium effect size. This reported greater usability likely contributed to the enhanced motivation and knowledge retention observed in the game-based learning group. These findings are consistent with prior research showing that serious games can reduce cognitive load while enhancing engagement (Sitzmann 2011). Studies have shown that well-designed games present information through interactive narratives and meaningful feedback, which helps learners process complex material more efficiently than passive methods such as video instruction (Plass et al. 2015).

The serious game-based learning also led to significantly lower perceived task load in key aspects such as mental demand and temporal demand. These findings suggest that the game presented information in a cognitively manageable way, potentially by offering guided exploration, pacing, and modular progression. Lower task load during learning may have helped participants focus better on the material and engage with it more deeply. Although the physical demand, effort, and frustration aspects of the task load variable did not differ significantly, the general trend favoured the serious game method across all TLX subscales, suggesting a more balanced and smooth learning experience.

Moreover, while participants in both groups showed significant increases in self-efficacy right after the learning experience (Post), with large effect sizes, only the video-based learning group experienced a significant decline after 4 weeks (Ret), while the game-based learning group maintained their gains. Although between-group differences at Ret were not statistically significant, the trend suggests that the game-based intervention may have a more stable long-term effect on learners' confidence in applying mould prevention strategies.

Despite the game group reporting slightly higher behavioural change scores after 4 weeks (Ret), the difference between the two groups was not statistically significant. This suggests that while serious games can enhance knowledge and motivation, these gains may not directly translate into real-world behaviour without additional reinforcement. Behavioural change is a complex outcome influenced by contextual, environmental, and social factors beyond knowledge and intention. The small effect size observed aligns with existing literature emphasising the challenge of achieving behaviour change through one-time interventions alone.

Although this study provides promising evidence regarding the effectiveness of serious games, several limitations should be acknowledged. Studies consistently highlight that self-reported data are prone to social desirability, recall errors, reference bias, and response-shift bias. For example, physical activity research notes that self-report methods possess several limitations in terms of their reliability and validity (Prince et al. 2008). In the following, behavioural change was measured via self-reported data collected 4 weeks post-intervention. It is susceptible to social desirability and recall biases. No objective validation (e.g., home inspections or behaviour tracking) was conducted to corroborate these self-assessments. Also short follow-up periods (commonly under 3 months) limit conclusions about sustained behaviour change.

This study did not incorporate gameplay-embedded learning analytics, which limits the ability to examine how participants interacted with the game and which specific behaviours or decision patterns contributed to learning outcomes. Game learning analytics can capture granular behavioural traces such as navigation paths, time spent on tasks, error correction patterns, and strategy use. These data offer objective insights that complement self-reports and support deeper analysis of cognitive and behavioural processes in serious game environments. Future work will integrate analytics dashboards and event-logging mechanisms into the game to enable more comprehensive assessments of learning mechanisms and real-world behavioural transfer. Although the findings support the effectiveness of serious games for mould-prevention education, the specific perceptual, contextual, and spatial cognitive mechanisms were not directly measured and should be examined in future research.

5 | Conclusion

This study demonstrates the educational potential of serious games for mould-prevention education and provides outcome-level evidence supporting their effectiveness in this domain. Both serious game-based and video-based learning improved knowledge and self-efficacy immediately after training. Only the game-based intervention sustained superior knowledge retention and intrinsic motivation after 4 weeks, alongside lower perceived task load and higher usability. Behavioural change did not differ between groups, indicating that improved cognition and motivation alone are insufficient to drive lasting household behaviour without additional reinforcement mechanisms. Beyond comparative performance, the key contribution of this work lies in proposing a domain-specific instructional rationale for mould-prevention education. Mould risk depends on micro-level household actions

that physically modify the indoor environment by altering ventilation, humidity, surface temperatures, and moisture accumulation. These processes require spatial diagnosis and situated decision-making rather than declarative recall. The serious game was therefore designed to allow learners to actively test environmental modifications and observe their consequences through immediate feedback. The superior long-term retention observed in the game condition is consistent with theoretical perspectives suggesting that interactive and spatially grounded learning environments may be well suited to mould-prevention education. However, the present study did not directly measure perceptual or spatial cognitive processes, and future research should examine these mechanisms explicitly.

From a public-health and housing-policy perspective, the findings indicate that digital learning tools can support large-scale mould-awareness and tenant-education initiatives, especially in high-risk residential environments. The divergence between cognitive gains and behavioural outcomes further suggests that effective mould-prevention education should integrate learning with structured reinforcement, such as follow-up prompts, in-home audits, or environmental checklists. Educational institutions and public agencies may therefore benefit from deploying blended strategies that combine the diagnostic strengths of serious games with procedural supports to sustain behaviour change. Future research should incorporate longer retention periods, objective in-game behavioural analytics, and post-intervention field measurements of household conditions to better capture real-world learning transfer. Expanding the intervention across different climatic regions and housing typologies will further strengthen its scalability and policy relevance.

Author Contributions

Abdollah Baghaei Daemei: conceptualization, investigation, writing – original draft, methodology, validation, visualisation, writing – review and editing, software, formal analysis, data curation, resources. **Zhenan Feng:** methodology, validation, supervision, software, writing – original draft. **Daniel Paes:** methodology, validation, supervision, software, writing – original draft.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Peer Review

For transparency, the peer review documents associated with this article are available at <https://doi.org/10.1002/jcal.70227>.

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Appendix A

Pre-test Part A: Demographic Information:

1. What is your age?

2. What is your gender?

- Male
- Female
- Non-binary/Third gender
- Prefer not to say

3. What type of house are you currently living in?

		
Apartment/Flat	Standalone house	Townhouse

Other:

4. How often do you play video games (on desktops, laptops, tablets, smartphones, or consoles)?

- Never
- A few times a year
- A few times a month
- A few times a week
- Everyday

Part B and C: Pre-test, Post-test, and Retention

Knowledge Questionnaire



This is a common mold picture that can occur in homes

1. Which areas in a bedroom are most likely to develop mold? List the specific spots where you believe mold is likely to develop in a bedroom (e.g., bed). You may list more than one spot.

2. Which areas in a bathroom are most likely to develop mold? List the specific spots where you believe mold is likely to develop in a bathroom (e.g., mirror). You may list more than one spot.

3. Which conditions are necessary for mold growth?

4. What temperature range (in °C) is most likely to support mold growth? From ___ °C to ___ °C

5. What humidity range (in %) is most likely to support mold growth? From ___ % to ___ %

6. What strategies can you use to prevent mold growth in your home? List the methods you think can work. You may list more than one method.

Intrinsic Motivation Inventory (IMI).

Think about the learning experience you went through and answer the questions below that assess how you felt during the learning.

	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
While I was learning this material, I was thinking about how much I enjoyed it.							
I did not feel nervous at all while learning.							
This material held my attention throughout.							
I will answer this questionnaire seriously so in this question I will choose DISAGREE for this statement.							
I think I understood this material pretty well.							
I would describe this material as very interesting.							
I think I understood this material very well, compared to other people.							
I enjoyed learning this material very much.							
I felt relaxed while learning this material.							
This material was fun to learn.							

NASA Modified System Usability Scale (NMSUS).

Think about the learning experience you went through and answer the questions below that assess the learning tool (game or video) you used.

	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	strongly agree
I thought the learning tool was easy to use.							
I think I would not need technical support to be able to use the learning tool.							
I found the various functions in this learning tool were well integrated.							
I found the learning tool to be consistent.							
I believe that most people would learn to use this learning tool very quickly.							
I found the learning tool was not difficult to use.							
I felt very confident using the learning tool.							
I do not need a lot of training on this learning tool in order to get going.							

NASA Task Load Index (TLX)

Think about the learning experience you went through and answer the questions below that assess how you felt during the learning.

How mentally demanding was the learning?

Very Low

Very

High

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How physically demanding was the learning?

Very Low

Very High

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How hurried or rushed was the pace of the learning?

Very Low

Very High

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How successful were you in accomplishing what you were asked to do during the learning?

Very Low

Very High

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How hard did you have to work during the learning to accomplish your level of performance?

Very Low

Very High

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How insecure, discouraged, irritated, stressed, and annoyed were you during the learning?

Very Low

Very High

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General Self-Efficacy Scale (GSE).

Think about the learning experience you went through and answer the questions below that assess your confidence in your ability to handle challenges and achieve learning goals.

	Completely false	Mostly false	Somewhat false	Neutral	Somewhat true	Mostly true	Completely true
I can always manage to come up with a mould prevention strategy for my home.							
I am confident that I can efficiently prevent mould from growing in my home.							
I know how to prevent mould from growing in my home.							
When I am confronted with a mould-growing issue in my home, I can usually find several solutions.							
I can usually prevent mould from growing in my home.							

Behavioural Change Questionnaire.

Think about the learning experience you went through and answer the questions below that assess how it has influenced your behaviours and daily practices.

	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
I regularly check for signs of mould in my home (e.g., in the bathroom or bedroom).							
I have implemented strategies I learned to prevent mould growth in my home.							
Since the learning experience, I have noticed positive changes in my behaviour regarding mould prevention at home.							
I regularly apply the knowledge I gained about mould prevention in my daily routine.							
I have taken specific actions at home based on what I learned.							