Assessing the Effectiveness of Game-Based Learning Versus Video-Based Learning for Mold Prevention Education

Abdollah Baghaei Daemei[1*], *Zhenan* Feng[1], and *Daniel* Paes[1]

[1]School of Built Environment, Massey University, Auckland Campus, New Zealand

Abstract. Indoor mold growth remains a persistent indoor air quality challenge with well-documented links to respiratory illness, damp housing, and reduced occupant well-being. While educational tools and interventions have been increasingly applied in the built environment to address issues such as energy use, safety, and general indoor air quality, comparable educational tools specifically targeting mold prevention remain largely absent. Also, evidence comparing interactive learning approaches with conventional formats remains limited. This study compares game-based learning with video-based learning for mold prevention education, using a pre- and post-test experimental design with 120 participants. Participants from the general public in New Zealand were randomly assigned to either a game-based or a video-based intervention, both of which delivered equivalent educational content. Outcomes included knowledge acquisition, self-efficacy, intrinsic motivation, perceived task load, and system usability. The game was compared with a video-based training condition serving as a control. Statistical analyses showed that knowledge significantly improved from pretest to post-test in both conditions, with no significant difference in immediate knowledge gain (post) between groups. However, participants in the game-based condition reported significantly higher intrinsic motivation and system usability, as well as lower perceived task load, than those in the video condition. These findings indicate that while both approaches support short-term learning, the serious game provides motivational and experiential advantages.

Keywords. Serious games, gamification, mold prevention, indoor air quality, education

1 Introduction

Air quality is a fundamental determinant of human health and everyday wellbeing [1]. While outdoor air pollution often receives greater public and regulatory attention, the quality of air inside buildings plays an equally critical role in shaping health outcomes [2]. People spend most of their time indoors, particularly in residential environments, which means that prolonged exposure to indoor pollutants can have cumulative and serious consequences [3, 4]. Exposure to poor indoor air quality has been repeatedly associated with a range of adverse health outcomes, including respiratory illness, worsening asthma symptoms, allergic responses, cardiovascular conditions, and diminished quality of life. These effects are particularly pronounced among children, older adults, and people with existing health conditions [5, 6].

Among indoor air quality stressors, mold represents one of the most persistent and complex challenges [7-9]. Mold typically develops in environments where moisture, insufficient ventilation, and cold surfaces coexist [8]. Once established, it releases spores and microbial by products that degrade indoor air quality and are associated with wheezing, asthma symptoms, respiratory infections, and hypersensitivity reactions [10]. Unlike many outdoor pollutants, mold exposure is strongly shaped by household level decisions and daily practices, such as heating, ventilation, moisture generation, and building use. As a result, mold prevention is not only a technical or regulatory issue, but also an educational and behavioral one [11, 12].

The New Zealand housing context highlights the urgency of this issue [13, 14]. A substantial proportion of the housing stock remains cold, damp, and poorly ventilated, particularly within the rental sector Consumer [15], [16]. National surveys and health statistics consistently report high rates of visible mold in homes, alongside elevated rates of respiratory hospitalization and childhood asthma Keall, Crane [17]. Environmental health data indicate that thousands of hospital admissions each year are associated with respiratory and cardiovascular conditions linked to poor air quality Environmental Health Indicators [18].

Education therefore plays a central role in addressing mold-related indoor air quality problems [19]. Improving residents' understanding of moisture sources, ventilation practices, thermal comfort, and prevention strategies can support meaningful reductions in mold risk [20, 21]. However, existing educational approaches remain largely passive [22]. Information is commonly delivered through

* Corresponding author: abaghaei@massey.ac.nz

brochures, websites, or instructional videos that rely on one way communication [23]. While such methods can raise awareness, they often struggle to sustain engagement, support decision making in context, or translate knowledge into action [24]. This limitation is particularly critical for mold prevention, where understanding must be applied dynamically within everyday household routines [25].

In response to these challenges, a growing body of research has explored the use of digital and interactive technologies for environmental and health education [26, 27]. Serious games and gamification have been shown to enhance engagement, motivation, and perceived competence across domains such as health education, safety training, and the built environment [28, 29]. By allowing learners to explore scenarios, test decisions, and receive immediate feedback, serious games support experiential learning approaches that are well suited to behavior-oriented topics requiring judgement rather than simple factual recall [30].

Despite this potential, the application of gamification to indoor air quality education remains limited [31, 32]. A recent systematic review identified only nineteen empirical studies published between 2009 and 2023 that applied gamification to air quality education [33]. Most of these studies focused on general pollution awareness or asthma management, often targeting children rather than the general public. Moreover, many studies relied on small sample sizes, lacked validated psychological and usability measures, and rarely drew on established learning or behavioral theories to guide design.

Importantly, the existing literature reveals a clear methodological gap. Very few studies directly compare gamified learning with conventional instructional formats such as videos or static digital content. Also, there is no studies focused on the application of gamification for mold prevention education [33]. As a result, it remains unclear whether serious games offer tangible educational benefits beyond increased engagement. Evidence related to self-efficacy, cognitive workload, usability, and behavioral change is particularly limited, and long-term knowledge retention is rarely examined.

This study positions gamification as a bridge between knowledge and action in mold prevention education. By embedding evidence-based content into an interactive serious game, it aims to support not only knowledge acquisition but also motivation, usability, and cognitive experience. Through a controlled experimental comparison between a game-based learning and video-based learning, this study responds directly to gaps identified in the literature and contributes empirical evidence to an under explored area at the intersection of indoor air quality, public health education, and digital learning design, with direct relevance to the New Zealand housing context and broader international challenges. The primary aim of this study is to compare the effectiveness of game-based learning compared to video-based learning on knowledge gain, improve self-efficacy, enhance task load and motivation, and system usability.

2 Methodology

2.1 Study Design

A pre- and post-intervention experimental framework was used to evaluate game-based learning in comparison with video-based instruction. Participants were randomly allocated to either the game condition or the video learning condition. Both formats presented identical educational material addressing mold-prone areas, critical growth conditions, recommended indoor environmental ranges, and prevention strategies. Measures of knowledge and self-efficacy were collected prior to and following the intervention, whereas intrinsic motivation, system usability, and perceived task load were assessed after completion of the learning activity (Fig. 1) [34].

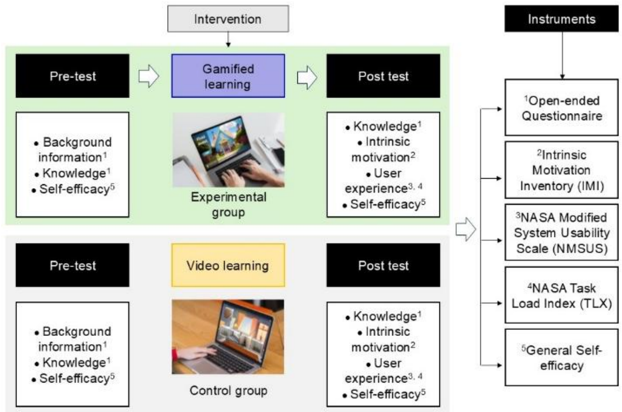


Fig. 1. The experimental design framework

2.2 Participants and Recruitment

Participants were enrolled through face-to-face recruitment of members of the general public in New Zealand using printed flyers distributed at public venues. Participation was entirely voluntary, and no prior training or professional experience in building science or indoor air quality was required. Inclusion criteria were restricted to adults who were able to read and understand English sufficiently to complete the study materials and survey instruments. In total, 120 individuals took part in the study, with 60 participants allocated to each experimental condition. To maintain data integrity, attention check items were incorporated into questionnaires. Responses from participants who did not correctly answer these items were removed from further analysis. Following this screening process, the final analytic sample comprised 110 participants, including 56 in the game-based learning condition and 54 in the video-based learning condition (see Fig. 2). Each participant received an NZD 10 supermarket voucher in recognition of their time and contribution. Participant characteristics, including gender, housing type, and frequency of video game use, are summarized in Table 1.

Fig. 2. Participants engaging in game (left) and video learning (right) sessions during the experiment

Table 1. 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%

2.3 Intervention

The serious game was developed using Articulate Storyline 360 and was designed to simulate common residential environments and mold-related decision-making scenarios. The game structure, learning objectives, and mechanics have been described in detail in Baghaei Daemei, Feng [35]. Figure 3 illustrates the picture of different parts of the game. The video-based intervention presented the same educational content in a linear instructional format, without interactive elements (see Fig. 4).

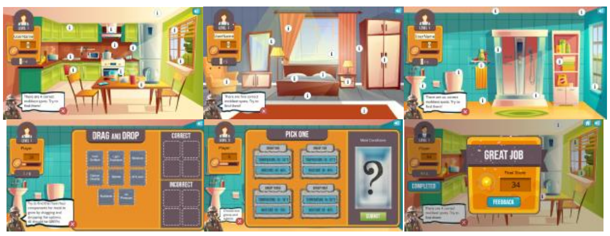


Fig. 3. Some screenshots of the game from different levels

Fig. 4. Screenshots of video training

2.4 Instruments

Participants' knowledge was evaluated using a test developed by the researchers and designed to reflect the educational material, with scores ranging from 1 to 30. Perceived self-efficacy was measured using a validated general self-efficacy instrument [36]. Intrinsic motivation was assessed following the intervention through the Intrinsic Motivation Inventory [37], covering interest and enjoyment, perceived competence, and pressure and tension subscales. System usability was evaluated using a standard usability measure [38], while perceived cognitive workload was assessed using the NASA Task Load Index [39]. To protect participant anonymity, no personally identifiable information was collected. Each participant was assigned a unique identification code, which was used exclusively to match pre- and post-intervention responses during data analysis.

2.5 Data Analysis

Data analysis was conducted using SPSS version 29. The reliability of all multi-item instruments was evaluated through Cronbach's alpha coefficients. To assess distributional assumptions, normality of the pre- to post-intervention change scores was tested using the Shapiro–Wilk procedure. Changes within each group were analysed using paired-sample t tests, while differences between groups were examined using independent-sample t tests. Effect sizes were estimated using Cohen's d, with within-subject effects reported as d_x.

2.6 Ethics

Ethical approval was granted by the Massey University Human Ethics Committee (Low Risk), approval number 4000030296. All participants provided informed consent prior to participation.

3 Results

This section presents the quantitative findings of the study. Data was analyzed using SPSS v29. Assumption checks indicated that pre post difference scores for knowledge and self-efficacy met normality requirements, allowing the use of parametric tests. Within group changes were examined using paired sample t tests, while between group comparisons were conducted using independent sample t tests. Effect sizes are reported using Cohen's d, with within subject effect sizes calculated as d_x.

3.1 Reliability Analysis

The internal consistency of all multi-item measures employed in this study was evaluated. Cronbach's alpha values were computed separately for the game-based and video-based conditions where relevant. Overall, the results indicate acceptable to good internal consistency across all measures, supporting the reliability of the instruments for subsequent analysis. The Intrinsic Motivation Inventory subscales demonstrated acceptable reliability in both conditions, with alpha values ranging from 0.71 to 0.89. The self-efficacy scale also showed good internal consistency at both pre-test and post-test stages. System usability and task load measures exhibited acceptable reliability, indicating consistent participant responses across items (Table 2).

Table 2. Internal consistency reliability of study measures (Cronbach's alpha)

Measure	Timing	Game (α)	Video (α)
Knowledge test	Pre	0.76	0.74
Knowledge test	Post	0.82	0.79
Self-efficacy	Pre	0.85	0.83
Self-efficacy	Post	0.88	0.86
IMI Interest Enjoyment	Post	0.79	0.89
IMI Perceived Competence	Post	0.77	0.73
IMI Pressure Tension	Post	0.71	0.76
System usability	Post	0.84	0.81
Task load	Post	0.78	0.80

3.2 Knowledge Outcomes

Both interventions produced significant improvements in knowledge from pre-test to post-test. In the game condition, knowledge scores increased from M = 4.14 (SD = 2.19) to M = 16.21 (SD = 4.86), representing a very large within-subject effect. Similarly, in the video condition, knowledge scores increased from M = 3.63 (SD = 1.77) to M = 15.85 (SD = 3.36). A comparison of knowledge gain scores revealed no statistically significant difference between the two conditions, indicating that both interventions were equally effective in supporting immediate knowledge acquisition (Table 3). Figure 5 shows the knowledge scores before and after learning in both conditions.

Table 3. Knowledge pre–post comparison

Group	Pre-test M (SD)	Post-test M (SD)	t(df)	p	Cohen's d_x
Game (n = 56)	4.14 (2.19)	16.21 (4.86)	20.52 (55)	< .001	2.74
Video (n = 54)	3.63 (1.77)	15.85 (3.36)	23.08 (53)	< .001	3.15

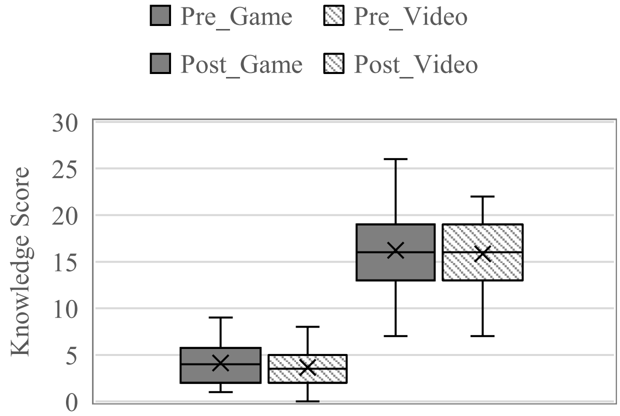


Fig. 5. Participants' knowledge scores in the game and video learning conditions (pre and post)

3.3 Self-Efficacy

Self-efficacy increased significantly in both conditions. Participants in the game condition showed a larger mean increase; however, both interventions produced large within-subject effects (Table 4). Figure 6 shows the self-efficacy scores before and after learning in both conditions.

Table 4. Self-efficacy pre–post comparison

Group	Pre-test M (SD)	Post-test M (SD)	t(df)	p	Cohen's d_x
Game	4.08 (1.25)	5.90 (0.77)	9.36 (55)	< .001	1.25
Video	4.51 (1.09)	5.87 (0.91)	7.40 (53)	< .001	1.01

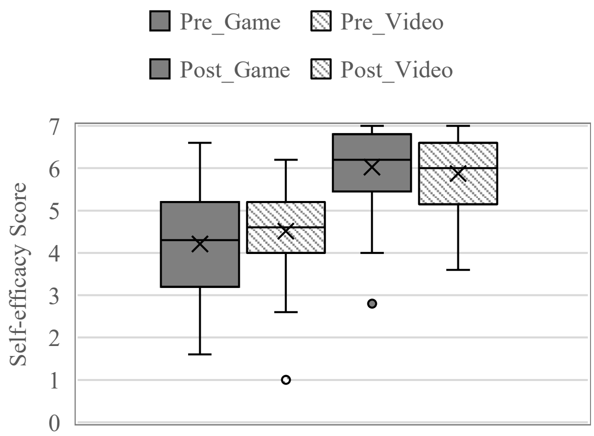


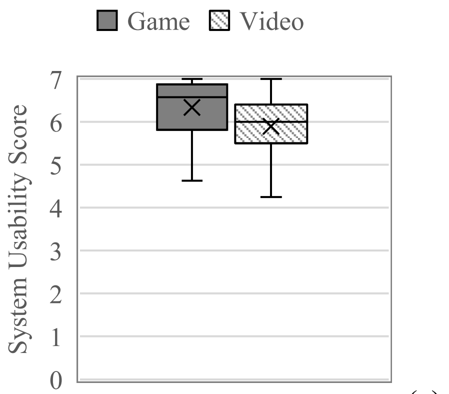
Fig. 6. Participants' self-efficacy scores in the game and video learning conditions (pre and post)

3.4 Intrinsic Motivation, Usability, and Task Load

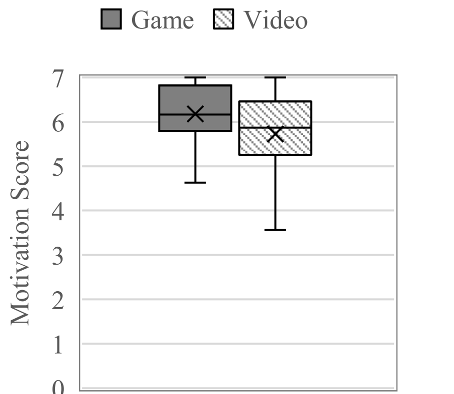
Post-intervention comparisons revealed significantly higher intrinsic motivation and usability scores in the game condition compared to the video condition. Participants in the game also reported significantly lower perceived task load (Table 5). Figure 7 shows the motivation, usability, and task load scores before and after learning in both conditions.

Table 5. Post-intervention outcomes

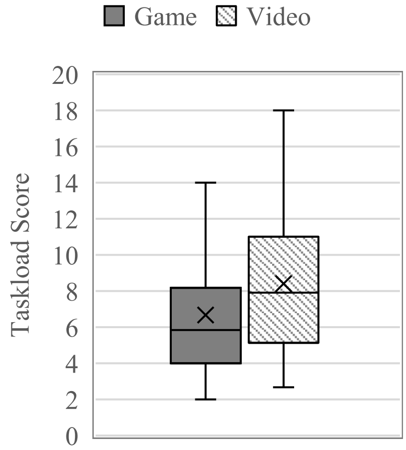
Measure	Game M (SD)	Video M (SD)	t(df)	p	Cohen's d
IMI (overall)	6.18 (0.70)	5.72 (0.93)	2.93 (108)	.004	0.56
Usability	6.33 (0.70)	5.89 (0.76)	3.14 (108)	.002	0.60
Task Load	6.67 (3.60)	8.41 (3.86)	−2.44 (108)	.016	−0.47



(a)



(b)



(c)

Fig. 7. Participants' system usability (a), motivation (b), and task load (c) scores in the game and video-based learning conditions (pre and post)

While intrinsic motivation and self-efficacy are not direct measures of physical mold-prevention behaviors, they represent theoretically grounded psychological antecedents of action. Self-efficacy, in particular, has been consistently associated with the adoption and maintenance of health-related practices, especially those embedded in daily routines. Mold prevention requires repeated micro-decisions, and these behaviors are more likely to occur when individuals feel capable of performing them effectively.

The lower perceived task load observed in the game-based condition may further support behavioral translation by reducing cognitive burden associated with understanding technical indoor air quality concepts. When environmental information is perceived as cognitively manageable, individuals may be more willing to implement physical strategies such as ventilation adjustments or moisture management. However, it must be emphasized that this study did not measure actual household practices. Therefore, the relationship between motivational constructs and real-world behavior remains inferential and should be examined in future studies using behavioral tracking or environmental indicators such as indoor humidity measurements.

4 Discussion

The findings of this study demonstrate that serious games are effective approaches for improving short term knowledge and self-efficacy related to mold prevention. Participants in both conditions showed substantial gains from pretest to post-test, indicating that the educational content was successfully communicated regardless of instructional format. Contrary to assumptions that interactive learning necessarily produces superior immediate learning outcomes, no significant difference was observed between the two conditions for post intervention knowledge gain. This finding is consistent with previous research showing that serious games often perform comparably rather than superiorly to traditional instructional approaches when short term knowledge acquisition is the primary outcome [40, 41].

Despite similar learning gains, clear differences emerged in experiential and motivational outcomes. Participants who engaged with the serious game reported higher intrinsic motivation, greater perceived competence, higher system usability, and lower cognitive workload than those who viewed the instructional video. These results suggest that the interactive nature of the game supported a more engaging and cognitively efficient learning experience. Reduced task load alongside increased motivation is particularly important for educational interventions targeting the general public, as excessive cognitive demand can undermine engagement and limit practical application.

These findings are especially relevant in the context of mold prevention, where knowledge must be applied dynamically within everyday household routines rather than recalled in isolation. While a video may effectively convey information, it does not allow learners to explore decisions, experience consequences, or practice judgement in context. The serious game, by contrast, enabled experiential interaction with mold-related scenarios, which may help explain the observed differences in motivation and usability.

Although this study did not directly measure real household behavior, the results suggest that the serious game has promising potential to support mold-prevention practices. Both the game and the video improved knowledge and self-efficacy, but the game also made the learning experience more engaging and cognitively manageable. This matters because preventing mold is not simply about knowing the facts; it requires confidence, motivation, and the ability to apply knowledge in everyday routines such as ventilation and moisture control. From a broader perspective, serious games could complement public health efforts by making indoor air quality education more accessible and engaging for the general public. However, future longitudinal studies are needed to determine whether these psychological advantages translate into sustained behavioral change in real-world settings.

Several limitations should be acknowledged. First, the study assessed only immediate post intervention outcomes. Knowledge retention over time was not examined, and it remains unclear whether the motivational advantages observed in the game condition translate into longer term learning or behavioral change. Second, while the sample size was adequate for detecting medium to large effects, a larger and more diverse sample would strengthen the generalizability of the findings. Third, behavioral outcomes were not directly measured, and future studies should examine whether increased motivation and usability lead to sustained changes in household practices related to moisture and ventilation.

The present study assessed only immediate post-intervention outcomes. Although substantial gains in knowledge and self-efficacy were observed, the durability of these effects remains unknown. This is particularly relevant in the context of serious games, where motivational advantages may be most meaningful for sustaining engagement over time rather than producing superior short-term knowledge gains. Longitudinal follow-up assessments are therefore necessary to determine whether the experiential benefits of gamification translate into improved knowledge retention and sustained preventive practices.

Additionally, frequency of video game use may influence perceptions of system usability. While demographic data were collected, the current analysis did not stratify usability outcomes based on gaming frequency. It is possible that participants who regularly engage with digital games may find interactive tools more intuitive, which could contribute to higher usability scores. Future analyses should examine moderation effects of digital familiarity to ensure that serious games for environmental health education remain accessible and effective for populations with lower digital literacy.

Future research should therefore focus on longitudinal designs that assess knowledge retention and behavioral outcomes over extended periods. Larger sample sizes and repeated exposure designs would allow for more robust examination of learning trajectories and engagement patterns. In addition, integrating objective measures of behavior or environmental conditions could provide stronger evidence of real-world impact.

5 Conclusions

This study provides empirical evidence comparing game-based learning and video-based learning for mold prevention education. Both approaches were effective in improving short term knowledge and self-efficacy, with no significant difference in immediate knowledge gain between conditions. However, the serious game demonstrated clear advantages in intrinsic motivation, system usability, and perceived task load, indicating a more engaging and user-friendly learning experience. These findings suggest that serious games should not be viewed solely as tools for increasing knowledge, but as educational environments that can enhance motivation and reduce cognitive burden. While videos remain effective for information delivery, serious games may be better suited to supporting sustained engagement with complex, behavior-oriented topics such as mold prevention. Future work should extend this research by examining long term knowledge retention, behavioral change, and scalability across diverse housing and population contexts.

References

1. Jacob, D.J. and D.A. Winner, *Effect of climate change on air quality.* Atmospheric environment, 2009. **43**(1): p. 51-63.
2. Tham, K.W., *Indoor air quality and its effects on humans—A review of challenges and developments in the last 30 years.* Energy and Buildings, 2016. **130**: p. 637-650.
3. Kim, J.H., et al., *Effects of environmental health literacy-based interventions on indoor air quality and urinary concentrations of polycyclic aromatic hydrocarbons, volatile organic compounds, and cotinine: A randomized controlled trial.* Atmospheric Pollution Research, 2024. **15**(1): p. 101965.
4. Hao, R., et al., *Emission characteristics, environmental impact, and health risk assessment of volatile organic compounds (VOCs) during manicure processes.* Science of The Total Environment, 2024. **906**: p. 167464.
5. Cheng, H., et al., *Home environment exposure and sick building syndrome (SBS) symptoms among adults in southern China: Health associations in 2010 and 2019.* Building and Environment, 2024. **248**: p. 111061.
6. WHO. *Health consequences of air pollution on populations*. 2019 [cited 2019 15 November]; Departmental news [Geneva, Switzerland]. Available from: https://www.who.int/news/item/15-11-2019-what-are-health-consequences-of-air-pollution-on-populations#:~:text=It%20increases%20the%20risk%20of,poor%20people%20are%20more%20susceptible.
7. Nature Editorial, *Indoor air pollution kills and science needs to step up.* 2023. **614**(Editorials).
8. Lewis, A.C., D. Jenkins, and C.J.M. Whitty, *Hidden harms of indoor air pollution — five steps to expose them.* Nature, 2023(614): p. 220-223.
9. Graham, F., *Daily briefing: We need a proper science of indoor air pollution.* Nature Briefing, 2023.
10. Boso, À., et al., *Out of sight, out of mind: participatory sensing for monitoring indoor air quality.* Environmental Monitoring and Assessment, 2020. **192**(2): p. 104.
11. Morawska, L., et al., *Mandating indoor air quality for public buildings.* Science, 2024. **383**(6690): p. 1418-1420.
12. Stokstad, E., *Asthma Linked to Indoor Dampness.* Science, 2004. **304**(5675): p. 1229-1229.
13. Rutledge, D. *New Zealand's indoor pollution levels exceed WHO safety guidelines 91 pct of the year - study*. 2024 [cited 2024 11 January]; Available from: https://www.newshub.co.nz/home/lifestyle/2024/01/new-zealand-s-indoor-pollution-levels-exceed-who-safety-guidelines-91-pct-of-the-year-study.html.
14. Dyson. *Global Dyson study1 reveals that indoor pollution levels in New Zealand exceeded WHO safe exposure guidelines for 90% of the year*. 2024 [cited 2024 11 January]; Available from: https://www.dyson.co.nz/newsroom/connected-purifier-study#:~:text=5%20levels%20in%20New%20Zealand,(8.46ug%2Fm%C2%B3).
15. Consumer. *Renter's guide - Dealing with mould*. 2023 [cited 2024 12th of April]; Available from: https://www.consumer.org.nz/articles/renters-guide-dealing-with-mould.
16. StatsNZ, *Housing in Aotearoa*. 2020.
17. Keall, M.D., et al., *A measure for quantifying the impact of housing quality on respiratory health: a cross-sectional study.* Environ Health, 2012. **11**: p. 33.
18. Environmental Health Indicators, *Asthma hospitalisations (0-14 years) [Factsheet]*, in *Wellington: Environmental Health Indicators Programme*. 2020, Massey University.
19. Moreira, A., et al., *AlergiaPT: A Portuguese media campaign to inspire people with allergies to make a positive change in their life.* Porto Biomedical Journal, 2022. **7**(1): p. e169-e169.
20. Fan, L., et al., *Indoor air quality of urban public transportation stations in China: Based on air quality evaluation indexes.* Journal of Environmental Management, 2024. **349**: p. 119440.
21. Li, P., et al., *Indoor air quality improvement with filtration and UV-C on mitigation of particulate matter and airborne bacteria: Monitoring and modeling.* Journal of Environmental Management, 2024. **351**: p. 119764.
22. Deslauriers, L., et al., *Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom.* Proc Natl Acad Sci U S A, 2019. **116**(39): p. 19251-19257.
23. Kuhlmann, S.L., et al., *Students' active cognitive engagement with instructional videos predicts STEM learning.* Computers & Education, 2024. **216**: p. 105050.
24. Milne-Ives, M., et al., *Potential associations between behavior change techniques and engagement with mobile health apps: a systematic review.* Frontiers in Psychology, 2023. **14**.
25. Krist, A.H., et al., *Engaging Patients in Decision-Making and Behavior Change to Promote Prevention.* Stud Health Technol Inform, 2017. **240**: p. 284-302.

26. Madani, K., T.W. Pierce, and A. Mirchi, *Serious games on environmental management.* Sustainable cities and society, 2017. **29**: p. 1-11.
27. Chen, J., M. He, and S. She, *The impact of environmental serious game on pro-environmental behavior through environmental psychological ownership and environmental self-efficacy.* Scientific Reports, 2025. **15**(1): p. 27616.
28. Douglas, B.D. and M. Brauer, *Gamification to prevent climate change: a review of games and apps for sustainability.* Current Opinion in Psychology, 2021. **42**: p. 89-94.
29. Johnson, D., et al., *Gamification for health and wellbeing: A systematic review of the literature.* Internet Interventions, 2016. **6**: p. 89-106.
30. De Jans, S., et al., *Using games to raise awareness: How to co-design serious mini-games?* Computers & Education, 2017. **110**: p. 77-87.
31. Baghaei Daemei, A., et al., *Prototyping a Serious Game to Enhance Indoor Air Quality Awareness Among the General Public in New Zealand.* E3S Web Conf., 2026. **689**: p. 05010.
32. Baghaei Daemei, A., *Towards a serious game approach for mold prevention education in New Zealand homes*, in *School of Built Environment*. 2025, Massey University.
33. Baghaei Daemei, A., et al., *Gamification for air quality education: A systematic literature review.* Building and Environment, 2025. **270**: p. 112526.
34. Daemei, A.B., Z. Feng, and D. Paes, *A Serious Game for Mould Prevention Education: A Comparative Study With Video-Based Learning.* Journal of Computer Assisted Learning, 2026. **42**(2): p. e70227.
35. Baghaei Daemei, A., Z. Feng, and D. Paes, *Developing a serious game for indoor air quality and mold prevention education in residential buildings.* Smart and Sustainable Built Environment, 2025: p. 1-36.
36. Luszczynska, A., U. Scholz, and R. Schwarzer, *The general self-efficacy scale: multicultural validation studies.* The Journal of psychology, 2005. **139**(5): p. 439-457.
37. Choi, J., T. Mogami, and A. Medalia, *Intrinsic motivation inventory: an adapted measure for schizophrenia research.* Schizophr Bull, 2010. **36**(5): p. 966-76.
38. NASA, *Usability, Workload, & Error*, in *NASA-STD-3001 Technical Brief*. 2023.
39. Kosch, T., et al., *A survey on measuring cognitive workload in human-computer interaction.* ACM Computing Surveys, 2023. **55**(13s): p. 1-39.
40. Wouters, P., et al., *A Meta-Analysis of the Cognitive and Motivational Effects of Serious Games.* Journal of Educational Psychology, 2013. **105**: p. 249.
41. Connolly, T.M., et al., *A systematic literature review of empirical evidence on computer games and serious games.* Computers & Education, 2012. **59**(2): p. 661-686.