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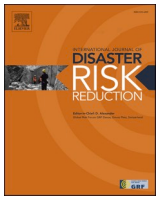

Exploring the use of the Quake Safe House video game to foster disaster and disaster risk reduction awareness in museum visitors

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ABSTRACT

This paper provides valuable insights into the use of disaster video games in museums. It contributes not only towards a better understanding of disasters within popular culture but also in fostering greater museum visitor participation in learning about disaster and disaster risk reduction (DRR). The theoretical background of this study draws on various scholarships from video game research, constructivist learning theory, and the museum learning environment. This research was undertaken in two New Zealand museums (Te Papa in Wellington and Quake City in Christchurch) which housed the disaster video game Quake Safe House (QSH). The research findings and associated discussion considers the potential of QSH to build disaster awareness based upon participants' gameplay. Ultimately, it is demonstrated that the use of 'serious' disaster video games, such as QSH, cannot be a stand-alone item for the purpose of learning within a museum space. Instead, such video games require better integration within the museum's environment and educational disaster displays to encourage and foster the participation of museum visitors in learning about disaster and DRR through multiple mediums.

1. Introduction

Disasters, associated with both natural and anthropogenic hazards, are increasingly popular themes for video games, which reflects the cultural dimensions of disasters in society [1]. However, while disaster video games can provide researchers with valuable insights into how people conceptualise disasters in their daily lives, there is limited research into portrayals of disasters within popular culture [2,3]. Previous disaster video game research indicates that disaster video games have the potential to instil disaster awareness through the portrayal of hazards, vulnerabilities, capacities and disaster risk reduction (DRR), with constructivist learning theory supporting the use of video games [2,4]. Gampell and Gaillard [2] connected game content for several disaster video games, both 'serious' and mainstream, to a DRR framework (prevention, mitigation and preparedness), identifying that further research into how game content, game mechanics, player skills, motivations and social interactions all contribute towards possible learning outcomes is required. Solinska-Nowak et al. [5] support the findings of Gampell and Gaillard [2] with their overview of 'serious' or educational (rather than mainstream) games for DRR, finding that several scholars prove 'serious' games and/or simulations have the potential to raise awareness and develop skills though quantitative and qualitative research is scarce surrounding the effectiveness of these games. Similarly, there is an identifiable gap in the effectiveness of conveying disaster preparedness education through museums [6] and in understanding how 'serious' disaster video games may contribute toward fostering the participation of museum visitors in learning about disaster and DRR. Accordingly, this paper provides valuable insights into the use of disaster video games in museums, while contributing not only towards a better understanding of disasters within popular culture but also in fostering greater museum visitor participation in learning about disaster and DRR.

2. Video games, constructivism and museums

Video games are increasingly popular amongst people of all ages, genders and ethnicity. Hence it is of no surprise that video games have globally become a fully integrated and vital part of contemporary culture, society and everyday life for millions of people [2,7]. As such, video games and games at large, have become powerful influencers not only for other video games but also movies, music and other forms of popular culture. The influential power video games have upon multiple

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dimensions of daily life demonstrates their ability to capture the attention of society, influencing culture but moreover their innate ability for active learning. Like the rapidly ever-changing technological future, people require twenty-first-century skills and competencies to be a twenty-first-century citizen [8]. Video games can be easily connected to constructivism and theoretically, seem to be advantageous in the attainment of building a player's awareness of various issues and skills [9–12]. However, while video-game theory fits with the principles of constructivism, game content, game mechanics, skills and motivations along with social interactions as a result of gameplay, can have a significant impact upon the learning experience. Similarly, Brabazon [13] suggests the use of digital media for strategic educational purposes in museums, often has poor deployment and is rarely considered a reflexive loop between teaching and learning, display and visitor, which again impacts upon visitor learning experiences.

Technology has a strong influence on education and learning practice [8]. Paliokas and Sylaiou [14] claim that broad adoption of 'serious' games into museums and cultural settings suggest 'serious' games can directly link target user groups to museum content to fulfil their educational needs. Such games draw upon the museum's characteristics and exhibitions, designed to complement, enhance or augment the museum experience [14] and can come in a variety of formats not limited to digital, physical, mobile, virtual and multi-player. As such, museums use such games to support constructivist learning through exhibit interaction [15]. However, Paliokas and Sylaiou [14] suggest visitor gaming experiences and museum impact is the core focus in a modern 'serious' game approach for museums, instead of positive learning outcomes, believing learning outcomes could be achieved through traditional approaches. However, MacDonald et al. [6] emphasise that scholars stress in order to increase students' motivation and engagement with material, both formal and informal instructional methods suitable for different learning abilities is required.

Naskali, Suominen and Saarikoski [16] comment that while the collective significance of video games and their history have emerged from 'the below' via everyday experiences and gamers, a growing trend demonstrates the institutionalisation of video games coming from the bottom-up. Hence, the complexity of modern-day requires museums to be reflexive and capable of repositioning cultural references [17]. For museums to facilitate learning, museums must provide consideration toward their audiences and the creation of spaces within the museum that can foster educational experiences for visitors [18]. Elwick [19] argues, in the context of implicit learning, that understanding the learning process when visitors enter the museum likely contributes to greater understandings of visitor experiences. In turn, such understanding can better cater for the learning needs of visitors [19]. Museums have therefore seen a shift from exhibiting and interpreting objects toward encouraging visitor interpretation, providing visitors with opportunities to observe, handle, interact and experiment with various objects [20], an approach strongly aligned with constructivist learning theory.

Constructivist learning theory asserts that learners with minimal instruction, construct knowledge including both individual and social meanings, based upon their own experiences and their reflection upon these experiences, through active engagement and self-regulation, challenging their current thinking and existing beliefs [12,21–25]. Constructivism assumes individuals are active learners who develop knowledge for themselves, either via exogenous, endogenous or dialectical constructivism [25] with Table 1 outlining guiding constructivist principles suggested by Hein [23]. Vygotsky's theory, a form of dialectical constructivism, considers the social environment as critical for learning while social interaction transforms the learning experience [25]. Vygotsky, compared to Piaget, emphasises the importance of social interactions upon learning, whereby knowledge is not constructed individually but co-constructed between two people [26]. Vygotsky also suggests the difference between achieving independent problem-solving compared to the potential problem-solving achievement with assistance from the more knowledgeable other is the zone of proximal development [25–27]. With appropriate instructional conditions, support and guidance, students can achieve higher learning potential and mental functioning [25,26]. Knowledge is not gained passively during such interactions, but rather learners bring personal understanding to the social interaction, constructing meaning via the integration of these understandings with their experience [25]. While not formally part of Vygotsky's theory, instructional scaffolding as termed by Wood, Bruner and Ross [28] fits within the zone of proximal development as an appropriate application to help increase the learner's competence, whereby the more knowledgeable other provides verbal or physical assistance and support to help the learner master a task or problem outside of their capabilities [25,26]. Such an application becomes an important consideration when considering the potential learning experiences by using a video game.

Table 1
Guiding principles of constructivism.

Principle	Explanation
Learning is an active process	Learner uses sensory input, engaging with the world to construct meaning. Learner is active, not passive.
People learn to learn while they learn	Learning by both constructing meaning and constructing systems of meaning.
Meaning construction is mental	Activities need to engage both the mind and physical action/hands-on experience. Reflective activity.
Learning involves language	Language and learning are intertwined, with the language used influencing how people learn. People talk to themselves while learning.
Learning is a social activity	Learning is associated with connections with other people, teachers, peers, family. Learning uses conversation, interaction with others and knowledge application.
Learning is contextual	Learning based upon existing knowledge, beliefs and experiences. Learning is not through facts and theories processed separately in the mind.
Knowledge is required to learn	Cannot assimilate new knowledge without a structure formed from previous knowledge to build on.
Learning takes time	Learning requires reflection, revisiting ideas, trying ideas and using ideas. Learning is a product of repetition and exposure.
Motivation is key	Motivation is essential for learning, which includes understanding the ways knowledge can be used. Without knowing the reasons why one can be less involved in using the knowledge instilled.

Source: Adapted from Hein [23].

3. A case study of Quake Safe House in the context of New Zealand

Quake Safe House (QSH) was an Earthquake Commission (EQC)[1] branded 'serious' disaster video game tasking players with preparing a Wellington hillside home for an earthquake. During the 2016–2017 period of this research, QSH was only available to the public as a physically installed interactive display located in two museums, Te Papa, i.e. the Museum of New Zealand in Wellington, as part of the Awesome Forces exhibit [2] and the Canterbury museum exhibit Quake City in Christchurch. Awesome Forces was an EQC sponsored free exhibit highlighting disaster risk and preparedness information with a walk-through shake house simulator [6]. Quake City charges an admission to explore the aftermath of the September 4, 2010 and February 22, 2011 Christchurch earthquakes, majorly sponsored by EQC [30]. Selby and Kagawa [31] indicate that disaster prevention education directly relating to local hazard risks and culture is most relevant to learners [6]. Given New Zealand's location upon the Pacific Plate boundary and the Australian Plate, tens of thousands of earthquakes

[1] A New Zealand Crown entity providing insurance to residential property owners alongside investment into disaster research and education [29].

occur annually [6]. This made QSH an appropriate game to explore how standalone video games, featured as part of a larger museum exhibit, may foster museum visitor engagement in building their awareness of disaster and DRR.

Documentation provided by EQC for the EQ-IQ/Quakehouse project,[2] which preceded the development of QSH, provides some potential context for the development intentions of QSH. An interactive graphic called Quakehouse, on the now unavailable EQC EQ-IQ website, aimed to engage New Zealanders (the audience/readers of the website) with EQC's prevention messages. Quakehouse enabled players to create earthquakes, with various intensities, with and without precautions to limit damage to their home and contents. Quakehouse provided players with clear instructions and feedback after the earthquake simulation about how to take preventative actions within their own home, linking players to areas of the EQ-IQ website (refer to Fig. 1). Quakehouse aimed to convert awareness into engagement and encourage action from New Zealanders to prepare for damage-causing earthquakes by providing information for them before, during and after an earthquake [31].

QSH locates the player in New Zealand, with a rugby ball on the roof of the house and Wellington city landscape in the windows. Using a touch screen, players drag and drop a range of preventative earthquake measures designed to reduce the damage to their home and contents. Players are provided with basic gameplay rules and the overall goal of QSH, but they are not provided with any specific instructions about the purpose of each preventative tool. Instead, players are required to work this out for themselves through gameplay. Gameplay lasts a total of 2 minutes and 20 seconds with players working through three scenarios with a set time limit: kitchen (50 s), lounge (50 s) and house exterior (40 s). Players drag the tools supplied on the sides of the game screen and drop them on specific objects like the bookcase or fish tank. At time-up the player observes the impacts of the earthquake with the suitability of tool placement indicated by being sequentially checked off with a tick or cross. A feedback screen is shown to players, providing overall scores for correctly securing each object in each scenario and an overall final percentage score (refer to Fig. 2).

No definite information was found to suggest the intended target audience for QSH, though the game could be played by both children and adults as demonstrated by the demographic of the research sample. Gampell and Gaillard [2] connected QSH to a disaster video game typology intended to reflect DRR content found in different disaster video games in terms of prevention, mitigation and preparedness. Gampell and Gaillard [2] found QSH connected to four aspects of DRR including prevention (use of manmade structures, engineering design), mitigation (engineering techniques/hazard resistant construction) and preparedness (disaster risk analysis).

4. Methodological approach

This paper primarily explores how the 'serious' disaster video game QSH, could foster museum visitor's learning about disaster and DRR. Data collection was conducted in Te Papa on 15–16 October 2016 and Quake City on 18–19 March 2017. The study took a qualitative approach, focusing upon understanding QSH and the gameplay experiences of museum visitors. Findings do not aim for statistical representativity but rather demonstrate patterns for how museum visitors think about and respond to a video game like QSH. In this paper, the research participants' perspectives of their interactions with QSH are used to examine the ability for 'serious' disaster video games to be utilised as a learning tool within the museum space.

The research drew upon semi-structured interviews (combining structured pre/post-game interview questions with informal post-game debrief conversations), playing QSH and researcher observations (Table 2). The research methods allowed participants to share their perspectives of QSH based on game content, game mechanics, player motivation, skill-building and social interaction and allowed researchers to derive insights into if and how playing 'serious' video games within a museum environment can build disaster awareness and knowledge.

Rather than asking every passer-by at the museum to participate for the sake of collecting data, participants were purposefully selected based upon whether they showed an interest in and approached the QSH display. If a museum visitor approached QSH, the researcher would approach the visitor and ask whether they would be interested in taking part in the research. The participants had no interaction with the actual QSH game other than approaching the game display prior to their participation in the study.

Twenty-two people participated in the study, with 11 participants recorded at each museum. Most participants belonged to the 22 to 25 age group (n = 7, six males and one female) followed by 26–30 (n = 4, equal split male and female). Collectively, the 41 to 50 (n = 3, one male and two female), 51 to 59 (n = 2, two female) and over 60 (n = 3, 1 male and two female) age groups totalled eight participants, with 11–12 (n = 1) and 13 to 18 (n = 2) totalling three female participants. Participants were mostly from Europe, commonly France, Germany and the United Kingdom alongside a few Australians who had recently immigrated to New Zealand. Notably, the total sample size for this research is small, especially given the high number of yearly visitors to Te Papa and Quake City for the 2016/2017 period (1,578,292 and 53,481[3] people respectively [33,34]).

5. Evaluating the potential of Quake Safe House to foster participation in learning

QSH was a standalone interactive video game display, located within a larger exhibit, competing with several other displays for the attention of museum visitors. In order to convey the intended messages of disaster prevention, QSH needed to attract and then subsequently engage the visitor through gameplay. The small sample size seemingly indicates that QSH was not succeeding in attracting museum visitors. However, it is apparent from the qualitative data collected that several patterns emerge from the research findings. Collectively, the participants' perspectives upon QSH in terms of game content, game mechanics, skills and motivations, alongside their social interactions as a result of gameplay reflect that these areas can have significant impacts upon the learning experiences of players. Therefore, in order to consider how QSH would foster participation in learning about disaster and DRR within the museum space, several variables require attention including the location of the QSH display, the space surrounding the display, the museum audience themselves and a focus upon the game content, mechanics, skills and motivations and social interactions of QSH.

Museums Aotearoa [36] asserts that the educational role of a museum lies at the core of their public service. Pre-game interview questions indicated participants would primarily access new information on earthquakes, the video game's hazard scenario, from the internet (n = 18), television (n = 6) and then school (n = 3). An 11-12-year-old female was the only participant to include books as a place to access new information about earthquakes, while a woman in her 50's indicated that her hotel in Christchurch had provided her with information surrounding earthquake safety measures. However, while no participants expressed they would use video games or the museum for learning new information. Yet, several participants did reference in their post-game interviews that their decision to play QSH was to learn more about earthquakes, what to do and also test their skills.

[2] EQ-IQ/Quakehouse was a website/interactive graphic designed as a place for New Zealander's to engage with EQC's messages around DRR action. This website is no longer available.

[3] This number is based upon available information that more than 190,000 visited Quake City over a period of three and a half years from opening in 2013 to the move to the new premises in 2017.

Fig. 1. Side by side comparison of Quakehouse interactive graphic. Left: instructions on how to use. Right: Results of unsecured home after a magnitude 8–9 earthquake.
Source: Etties [32].

Fig. 2. Images of Quake Safe House game. Top left: Wellington hillside home location. Top right: Quake Safe House game rules. Bottom left: Quake Safe House game instructions and gameplay demonstration. Bottom right: Consequence of player's actions and feedback.
Source: Author's Own, 2016.

Nevertheless, the post-game debrief indicated that their principal purpose for visiting their respective museum was for learning, either to learn more about New Zealand in general or in particular, the 2011 Christchurch earthquake. One participant from Western Australia, now residing in Christchurch, commented that they were visiting Quake City to learn more about earthquakes should they experience an earthquake while living in Christchurch. The post-game debrief conversations indicated that the QSH display and game was not interacted with by New Zealanders over four days in two different cities/museums but instead primarily foreign tourists or people who had recently migrated to New Zealand. This could suggest why the participants did not specifically include museums as places to learn new information for educational purposes but instead considered the museum as a tourist destination. Therefore, while education may be at the core of a museums

Table 2
Summarised methodological framework for the video game trial research process.

Method	Detail	Outcome
Structured pre-game interview questions	- 13 short answer questions informed by pre and post-game questionnaires from 2007 RiskRed report on Stop Disasters: Fire scenario and Darfur is dying survey reasoning document [35]. - Approx. three minutes.	- Attain existing video game habits and pre-game understandings of DRR strategies. - Provision of relevant hazard safety measure examples from their knowledge relating to earthquakes.
Play Quake Safe House	- Unassisted gameplay in line with constructivism. - Gameplay lasts 2 minutes and 20 seconds. - QSH played at least once, sometimes twice.	- To provide participants with material to answer the post-game questions and replicate typical play experiences. - Assumes learners with minimal instruction can construct knowledge, based upon their own experiences and their reflection upon these experiences, through active engagement and self-regulation, challenging their current thinking and existing beliefs [12,21–25]).
Structured post-game interview questions	- 16 short answer questions informed by preliminary content analysis of QSH by Gampell and Gaillard [2] and EQ-IQ website/Quakehouse information. - Approx. five minutes.	- Participant perspectives of QSH (scores, game content, mechanics, skills, motivations, social interactions) and readdress understandings of DRR strategies post-game. - Provision of new DRR strategies from QSH not known previously for pre and post-game comparison. - Provision of DRR strategies not featured in-game for any natural hazard more relevant to everyday life.
Post-game debrief	- Instigated by the participants post-game. - Timeframe and questions dependent upon the participants.	- Informal post-game debrief conversations. - Allowed those on ethical limitations like being too young to formally participate due to parental consent then personal assent requirements to informally discuss gameplay experiences and insights into QSH.

public service, one cannot dissociate that the museum is also primarily a tourist attraction.

The assumed goal of QSH, as derived from the EQ/IQ website and Quakehouse, was to build greater public engagement with strategies that individuals can employ to reduce damage to their homes and contents from a specific hazard (earthquakes) rather than DRR more broadly [32]. The preliminary content analysis of QSH suggested that two of the possible four actions of prevention were demonstrated within the game, namely the use of human-made structures and engineering design. Pre-game, three Te Papa participants and nine Quake City participants gave variations of drop, cover and hold, like '*Get under a table. Run outside into an open space if possible.' and '[Hide under] the table. Protect [your] head. If time keep phone close to head.*' seemingly indicating that participants had potentially more exposure to preparedness strategies versus engagement with prevention messages (refer to Table 3). Only two participants from Te Papa referenced preventative measures pre-game including one female participant in her 40s commenting '*Attaching heavy objects to walls or floors, making sure [the] house is attached to foundations*' and one male over 60 noted '*Secure anything that can fall over*'.

The pre/post-game comparisons show questionable awareness improvements. Post-game, participants indicated increased prevention awareness, often realising the gaps within their existing knowledge and interest in learning more about the tools used within the game. The findings show an increase of responses relating to prevention and securing objects. However, only seven participants (one Te Papa and six Quake City) could specify objects to be secured, preventative measures or tools used in the game or objects. While 17 participants provided relevant DRR strategies pre-game, only nine participants could recall new strategies obtained from playing QSH. Yet, some individuals pre-game claimed to have a basic understanding of earthquake preventative measures and post-game a complete understanding, or very little to basic understanding but did not provide definite examples of prevention strategies.

In terms of game content, QSH was generally well-received. Participants believed the game content was relevant and appropriate in terms of raising their awareness about the type of household actions to prevent earthquake-induced damage. However, eight participants felt that the game needed to provide players with more in-game information or instructions specifically regarding each tool and its use within the game (how it should be employed by the player to achieve the goal of the game). One 51–59 year old female participant from Quake City commented an improvement to the game would be '*Explanations about how the solutions would work*'. This comment is a crucial consideration for the development of a video game intended for the museum environment, especially in situations where games (like QSH) are used in more than one location. The walls at Te Papa surrounding QSH did provide information regarding the in-game tools and what players could use them on. However, participants rarely read the surrounding display information. Often the Te Papa participants only realised the information about QSH and earthquake damage prevention strategies were available to them on the walls post-game with direction by the researcher. In contrast, the walls surrounding QSH at Quake City were bare and did not provide visitors with any QSH related signage or any information relating to the game (refer to Fig. 3). Considering most participants were foreign tourists, a fundamental flaw exists surrounding the language and vocabulary for those interacting with QSH. Six participants commented upon the necessity for the game to have alternative languages other than English. During a post-game debrief, the researcher directed one participant to the information at Te Papa. The participant attempted to translate the information, however there was no equivalent translation to some of the words used. As one participant notes '*Easy to understand [the game] but vocabulary [is not]*.' Thereby, presenting another level of confusion to the game content for foreign visitors. Although, this could equally impact New Zealand residents should English be a second language and therefore may work against the intended goals of QSH.

The game mechanics of QSH brought some level of frustration to all participants demonstrated in gameplay observations and post-game debrief, though not always recorded in the structured interviews. With the vast improvements to touch screen technology and the daily usage of smartphones with more intuitive control, participants initially struggled

Table 3
Knowledge of DRR strategies indicated by participants.

DRR strategies	Pre-game	Post-Game
Drop, cover, hold	12	0
Secure objects	2	10
Go to an open area/evacuation point	5	0
Don't know/no answer	5	11

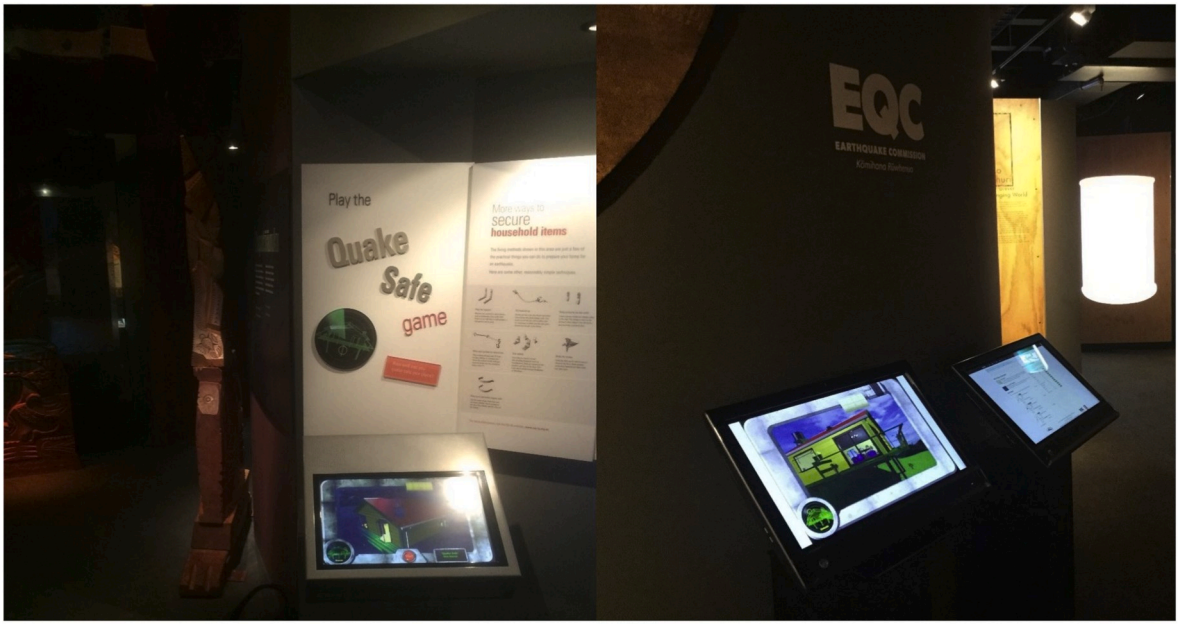

Fig. 3. Location of Quake Safe House display and surrounding area. Left: Te Papa. Right: Quake City.
Source: Author's Own, 2017.

with moving the game screen. The drag and drop mechanics of the game felt clunky and the lag often resulted in participants accidently locking a tool onto an incorrect object due to moving their finger too fast across the screen. As such, the game mechanics played a significant role in the initial scores of participants unable to work out how to move the screen via the two arrows at the bottom. One 22–25 year old male participant commented '*[QSH] was quite poorly designed. You [can't] reverse a safety tool once [you] put [it] on an item. The camera is slow which makes the time limit [go] even faster. You can't scout the room before pressing the start button.*' Participants thought the game's objectives were easy to figure out (n = 16). Collectively, instructions were clear to understand with an average of 3.6, on a scale of 1–5 where 1 is very unclear and 5 very clear. The feedback at the end of each scenario was appropriate (n = 17). However, several participants wanted more detailed information and the ability to learn more about the correct tools or why their chosen tool was inappropriate. Participants were frustrated with the short time limits placed upon each level, as they struggled to find the specific objects to interact with, moving the screen was not quick enough, and the lack of in-game information about each tool meant participants were unable to rationalise and understand what the specific tool they were selecting could achieve. Participants were also uncertain as to which objects within the game environment needed to be secured, often becoming stuck on the initial screen and not realising or having difficulty to move the screen using the arrows in the appropriate direction before the time ran out. An improvement suggested by an over 60 female was '*No time limits, [need] time to think and understand.*' Similarly, a 22–25 year old female suggested '*Dark out the arrow which way you can't move. Not so fast to think about [what to do] before you act. Show what [object] is important.*' These mechanics potentially contributed to the participant's limited learning outcomes.

Participants demonstrated some improved skills post-game, including physical skills, like being able to interact with the game screen, but also having attained new knowledge around various prevention measures. One 22–25 year old male participant noted '*Need to fix [the] oven [and] fridge if I had a house here.*' suggesting a conversion of awareness toward an engagement with prevention messages and potential to use this knowledge to act accordingly. 16 participants felt that after playing QSH, they had an increased understanding of preventative actions to take for an earthquake. Though in some cases, following gameplay, three participants felt they knew less than they initially thought and three were unchanged. In general, participants only played QSH once and were unmotivated to play the game a second time to improve upon or utilise their newly developed knowledge or skills. 19 participants finished their first playthrough of QSH with a score of 52% or below. Six participants, two males 22–25, one male and female 26–30, one female 41–50 and one female over 60, were motivated to play a second time and generally improved upon their original score by approximately 20–30% due to their increased understanding of the game's mechanics and knowledge of the in-game tools. The reason for the lack of participant motivation and hesitance to play QSH a second time stemmed from several issues surrounding game design and mechanics as elaborated in the previous paragraph. One participant expressed that '*Something need[s] to be put in to encourage players to replay the game.*' Participant further revealed they did not necessarily intend to interact with QSH. Instead, QSH was mistaken as either an internet access point, the earthquake house simulator at Te Papa or the GNS interactive display at Quake City (identical display unit housing a screen positioned immediately next to QSH).

Participants gave interesting insights to their perspectives regarding social interaction. Out of 10 male participants, seven preferred playing games cooperatively generally within the 22–30 age group. In contrast, from a total of 12 females, only one female participant from the 13–18 age group preferred to play games cooperatively. While these findings suggest participants prefer not to play games cooperatively, researcher gameplay observations were noticeably different. All participants who were accompanied by family or friends, immediately upon starting QSH called to these people to play with them and help them play the game. Conversing with different participants about this observation revealed, having prior experience with other video games was considered valuable. Hence, individuals commanding such knowledge became the more knowledgeable other providing support and guidance. Participants did mention the enjoyment of competitive games, which while QSH does not have a competitive function, some of the more competitive participants wanted to try improving upon their original scores and when accompanied by family and friends encouraged them to try to beat their scores.

One participant's perspective seems reflective of the outcomes for the research on QSH suggesting '*Personally it was raising my awareness of what objects in the house are dangerous in [the] event of earthquake. While*

the game did inform me of what tools could be used for prevention, I do feel that information will be forgotten quickly. One bad thing is that I will be taking in a lot of information in a museum visit.' Table 4 summarises the collection of participants' perspectives and learning experiences, reflective of constructivist principles. Table 4 mirrors this participant's response to principles of constructivism, demonstrating that QSH, like the participant denotes, has potential to impart relevant information, specifically for the intended purpose of drawing attention to messages of prevention. However, greater attention is required to ensure the museum environment can help facilitate the possible learning experience a video game can provide museum visitors.

6. Learning about disasters through video games in New Zealand museums

The research findings demonstrate that QSH does connect to constructivist principles (Table 4), acknowledging previous scholars' connections between video games and learning theory. However, while a video game like QSH can potentially foster the participation of museum visitors in learning about disaster and DRR, the research findings allude to a significant setback. Interestingly, the findings in Table 3 indicate improved awareness of prevention measures rising from two participants pre-game to 10 new participants post-game (3 Te Papa and 7 Quake City). However, uncertainty still surrounds whether a video game installed within a typical museum environment is effective at converting the intended messages to the museum visitor. Participant perspectives seem to indicate more information and instruction is required to fully understand the preventative strategies and measures. A significant benefit of this research is an ability to utilise the perspectives of participants to give greater insight toward the design of video games for a museum environment.

Table 4
The influence of Quake Safe House upon the learning experience of museum visitors with consideration to constructivist principles.

Constructivist Principle	Quake Safe House influence upon learning experience
Learning is active process	• Active participation by playing. • Interaction with different prevention tools in-game. • Interaction and control of in-game camera.
People learn to learn while they learn	• QSH bound by rules, rules influence player decision making and actions. • Time limit requires player decisions upon appropriate prevention tool to minimise damage during an earthquake. • Rules learnt through initial tutorial and gameplay of three different scenarios.
Meaning construction is mental	• Hands-on activity requires active participation. • Decisions made based upon player understanding and subsequent actions.
Learning involves language	• English language and New Zealand context. • Requirement to read and understand English. • Specific vocabulary related to disaster prevention. • Cooperative situations can encourage dialogue with partners, family members, talk to themselves or translation software to guide through thought process.
Learning is a social activity	• Mainly a single-player game. • Can be played cooperatively, players discuss, express ideas based upon past experiences with shared control or one controls while the other instructs.
Learning is contextual	• Utilise past knowledge and experience from various situations – other video games, technology, disaster awareness.
Knowledge is required to learn	• Real world/game world governed by rules, understood by players. • Knowledge of rules used to build further knowledge and understanding.
Learning takes time	• Experiment with ideas surrounding disaster prevention. • Repetitive gameplay allows better understanding, build confidence, ability and knowledge to improve scores.
Motivation is key	• Attain high score motivated players. • Game did not motivate repetition of gameplay. • Repetitive players motivated to play again demonstrated improved scores and understanding, compared to original play through – suggests players learnt something.

QSH was designed to reflect a Wellington hillside home, and most probably with the New Zealand public in mind. However, the intended QSH target audience does not reflect the audience visiting the museum. This research revealed New Zealanders did not interact with QSH over four days in two different cities/museum but primarily foreign tourists. The annual reports of both Te Papa and Canterbury Museum support these observations. The annual 2016/17 annual report for Te Papa indicates 43% of the total 1,578,292 visitors to the museum were international visitors [33]. Likewise, the majority of Quake City's visitors in the 2016/17 period were tourists (who comprised 73% of all visitors to the Canterbury Museum and Quake City) [34]. Several participants commented that where they reside overseas, earthquakes are not a major hazard. However, the Quake City museum dedicated to the 2011 Christchurch earthquake receives paying visitors interested in learning more about earthquakes and the events of 2011. Four participants from Quake City referenced their reason for playing QSH was to learn about earthquakes with one 22–25 male participant commenting he was '*Curious and never had [experienced an] earthquake and what to do [it was the] best way to imagine what happens*'. With 11 participants having paid to visit Quake City for the purpose of learning about earthquakes, seven of these participants post-game recalled earthquake prevention strategies not previously known. Therefore, a lack of improved awareness levels about earthquake prevention does not appear to stem from being a tourist. Ultimately, regardless of how the video game visually connects with New Zealand, the underlying constructivist process as outlined in Table 4 should be occurring.

Noticeably, participants often struggled to make sense of QSH's purpose, which no doubt impacted the ability of participants to demonstrate an improvement of their earthquake prevention understanding as seen in the findings. As a process instructional scaffolding, a component of the zone of proximal development, enables the learner to solve a problem or achieve a goal beyond their unassisted efforts [28, 37], therefore increasing the learner's competence. Effective scaffolding incorporates the concept of fading [37]. The learner with a grasp of a target skill, continues practicing by successfully executing the skill with limited hints and feedback from the master (fades) [37]. Participant perspectives indicate QSH was unable to provide effective scaffolding for visitors to learn about earthquakes and how to reduce the damage earthquakes may cause within a household setting. Issues with the game mechanics including time limit, moving the screen, the drag-drop feature, uncertainty about what objects are to be interacted with and needing further instructions about the content all work against ability of QSH to provide participants with the preliminary skills to apply to subsequent game challenges. Participants were unable to practice the skills necessary for gameplay or learn how to use each tool in the game before they played the game, impacting not only the older generations but also younger participants. Without this learning process or scaffolding, the purpose and potential to build awareness of earthquake prevention measures and understandings were not fully realised through playing QSH. Given that QSH represents the zone of proximal development, implementing an effective instructional scaffolding system would give participants the guidance to learn new information [11] and strengthen connections with the constructivist learning process.

Constructivism suggests that learning takes time and motivation is key. Significantly, the three sections of gameplay in QSH last a total of 2 minutes and 20 seconds. Several participants commented upon the short time frames indicating that more time was needed to digest the information and think about their actions. Therefore, the timeframe could be a factor in participants building a complete understanding of the content

and more importantly understanding what they were attempting to achieve. An observation of a younger museum visitor playing QSH demonstrated a clear understanding of bracing the house, something several older participants got incorrect. The visitor suggested they knew what to do as they played a bridge building game at home. A bridge designed with triangles is stronger than one without triangles. Therefore, the young visitor applied their prior knowledge and experience from the bridge building game (a form of zone of proximal development that provided the initial instructional scaffolding) into making the correct tool decision to brace the house. Thereby, experimenting with existing knowledge to confirm the accuracy of their understanding. Klopfer et al. [11] suggest that the application of knowledge learnt in one context is difficult to transfer to another context. Although, the visitors response suggests this knowledge and understanding had been built over a period of time with repetitive gameplay experiences. However, only six participants were motivated to play QSH a second time. All repeat participants increased their overall game scores implying they had 'learnt' something from their previous gameplay. Notably, the remaining 16 participants were unwilling to reengage with QSH for another 3 minutes to try improve their scores. As such, it is questionable whether learning can actually occur from playing a video game if the video game is only played once rather than through repetitive gameplay as constructivism outlines.

Evidently, the research findings seem to indicate that the QSH display was somewhat ineffective at not only capturing visitor attention, and the game design may have also contributed to low interaction levels. A significant difference between a 'serious' video game in a classroom versus a museum environment is the fact there is no teacher or facilitator to help foster the learning process in a museum. Instead, the video game must capture the visitor's attention and motivate the visitor to continually reengage with the display. In contrast, a video game can be a set classroom task with repetitive gameplay sessions. A video game like QSH is surrounded by several other displays and is continually competing for the attention of the museum visitor. While several participants liked the graphics of QSH, one 26–30 year old female participant commented '*If clipart could make a game this is what it would look like*' indicating the graphics were unappealing, needing improvements to both the graphics and user interface.

One should refer back to the everyday usage of a video game. Video games are ultimately a fun activity, often played socially, which are not explicitly designed for an educational purpose [38], yet can often satisfy the nine principles of constructivism as outlined in Table 4. Such video games, no matter whether they are designed with the casual player in mind or an AAA video game title (analogous to a blockbuster film) for a more experienced player, capture the players' attention, motivating the players to continually return to the game over a period of time. In respect of popular culture, classic and retro video games and consoles are experiencing a resurgence by not only nostalgic generations but also new generations [39,40]. Yet, it is unlikely 'serious' video games would achieve similar standings. Significantly, affinity groups can emerge from mainstream video games which may involve metagaming [38]. Such social interactions, social learning and metagame learning of frequent gamers, reflect the connections to constructivist principles and may therefore lead to improved learning experiences and motivations for repetitive play. DNZ16 [41] suggests New Zealand males in 2016 had been playing games for five years longer than females, 15 years versus 10 years. Commenting that 75% of people would prefer to play alone; however, 38% of people will play games with their partners while in the same room [41]. Observations during this research often saw female participants calling to their male partners to advise and play QSH with them, even though females were noted as not preferring to play games cooperatively. Importantly, such interactions and experiences were of immense value to those participants who worked cooperatively with a partner or group. Observations saw participants have discussions about the tools, how to move them around the game and attempts to apply personal past experiences and knowledge to the situation at hand.

The construction of knowledge occurs, as Meece and Daniels [26] argue, through a process of co-construction; by interacting with others, people create knowledge (rather than doing it individually). Participants drew upon their partners, friends and family members (more knowledgeable other) when playing QSH to provide them with verbal or physical assistance that helped them complete the game, another component of the zone of proximal development. Without the more knowledgeable other, it was likely that some participants would not have understood how to play the game (as it was outside their current capabilities) [25,26], and the available instructional scaffolding within QSH was inadequate to support these participants. These observations support Vygotsky's theory that the social environment is critical for learning and social interaction transforms the learning experience [25]. However, QSH was not designed to adequately support social learning in the museum environment. Therefore, video games within a museum environment may require reconceptualising.

For museums to facilitate the learning process and foster educational experiences inclusive of all visitors, consideration toward the museum audience and the creation of spaces within the museum is required [18]. It is this gap highlighted by Demski [18] that may hold true for the findings of this research upon QSH within the museum space. Unlike a museum-based disaster education program which could be specifically directed toward New Zealand-based students, teachers and parents [6], QSH is situated among numerous other exhibits and displays. Brabazon [13] comments that digital media can be used for strategic educational purposes, except deployment is poor and rarely considered a reflexive loop. This aligns with the participant's perspective about the amount of information a visitor confronts during a museum visit and new information may be forgotten quickly. Therefore, a standalone 'serious' video game within a museum environment needs to be memorable, engaging and connected to the surrounding displays. Reflecting upon the connections of metagaming and constructivist principles, the research observations reflect the disconnect in deployment, where developers in collaboration with museum curators missed an opportunity, to better direct museum visitors interacting with QSH toward the information and messages engaged with in-game that were displayed at Te Papa, while there was no information available at Quake City. The participant's comment regarding loss of knowledge inadvertently reflects the positions of Brabazon [13], Demski [18] and Hein [42], and the author's findings. Therefore, a necessary improvement to how museums present and use video games would be to ensure there is a connection of the video game to the surrounding exhibit.

It is crucial for QSH, as a standalone interactive video game display, to not only foster interaction between QSH and museum visitors but also direct the visitor back to information in the wider exhibit. Importantly, QSH should not be a disconnected activity from the wider exhibit, but in the absence of a teacher or facilitator the wider exhibit may be required to guide the museum visitor. Notably, the final feedback screen of QSH referred visitors back to the non-operational EQ-IQ website. Evidently, participants were unaware of the information associated to QSH on the walls at Te Papa, though QSH also did not refer back to this information in the feedback screens. Given the interest and motivation to learn about earthquake risk reduction activities by Quake City visitors, they had no method to seek further information. Furthermore, there needs to be a level of consistency toward how video games are curated within the museum space. Video games cannot just be added in as an interactive activity, but rather need to be installed in a way that is clear and easily replicated in subsequent museum exhibits. Such video games need to be well-supported by information that provides clarity for museum visitors about the games purpose and where they can gain further information to enhance their learning experience. The provision of such supporting material, in line with the constructivist learning framework discussed earlier in this paper, would allow museum visitors to extend their learning about DRR, with individual's learning about a subject built step by step, with allowances for social learning, and subsequently putting this learning into practice through gameplay.

7. Concluding thoughts on learning through disaster video games in museums

This paper draws attention toward the prospect of museum visitors, improving their awareness of disaster and DRR using a 'serious' disaster video game Quake Safe House. The connection of 'serious' disaster video games like QSH to constructivist learning theory suggest an ability to foster the participation of museum visitors in learning about disaster and DRR. However, further improvements especially surrounding the game design and presentation of the museum exhibition is required to better connect museum visitors who engage with 'serious' disaster video games with accessible information upon leaving the museum.

While the intentions of QSH may have been to increase engagement and awareness of preventative measures, the overall QSH display was not adequately positioned to ensure the museum visitor could engage with messages of disaster, DRR and specifically in the case of QSH prevention. While some participants demonstrated an improved level of earthquake prevention awareness, there were no opportunities for further engagement and reflection after leaving the museum. It is questionable as to whether museum visitors who engaged with QSH would be able to recall and translate their engagement with preventative strategies into action once outside of the museum environment. Parallel to the suggestions put forward by Macdonald et al. [6], further research into methods which extend the video game players engagement with disasters and DRR following their interaction with a disaster video game museum exhibit would be beneficial. With consideration to constructivism, the provision of a pathway for continued reflection and actions once back home would allow an extension of learning time and connection to a relatable context.

This paper highlights several factors which require careful consideration to avoid future 'serious' disaster video games intended for the museum environment falling into similar pitfalls. More attention toward the mechanics of the game and increasing player motivations to use the game are essential aspects to consider to further visitor engagement. More attention should be given toward how a video game, like QSH, could be best incorporated into an exhibition space, and potentially in other museum spaces. Focusing upon how the video game and display collaboratively best contribute to the learning opportunities of museum visitors is required, ensuring that associated information in-game is also reflected outside of the game. Provisions should also be made to consider the museum audience versus the target audience, including alternative languages, to create a more inclusive experience.

An opportunity therefore exists to engage a range of stakeholders, including representatives of the potential museum audience, in a collaborative process toward creating a video game with attention to game design in terms of game content, mechanics, skills and motivations and social interaction. In addition, exploring the location of the video game within an exhibition and the space surrounding the video game display. Importantly, this process cannot be undertaken solely by external stakeholders but must include the representatives of the everyday museum visitors. As Brabazon [13] and Hein [42] note people enter the museum space with preconceived ideas of what is popular and appealing, like the participant commenting about the graphics of QSH. Such perceptions can differ between individuals and social groups and may be challenging to cater to all. However, by bringing together a diverse set of stakeholders to develop more attractive and engaging 'serious' video games and displays for the purpose of the museum environment can lead to potentially improved uptake of the intended learning objectives reflective of constructivist learning principles.

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Appendix A. Supplementary data

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References

[1] G.R. Webb, The popular culture of disaster research, in: Handbook of Disaster Research, Springer, New York, 2007, pp. 430–440 (New York).
[2] A.V. Gampell, J.C. Gaillard, Stop disasters 2.0: video games as tools for disaster risk reduction, Int. J. Mass Emergencies Disasters 34 (2) (2016) 283–316.
[3] E.L. Quarentelli, I. Davis, An Exploratory Research Agenda for Studying the Popular Culture of Disasters (PCD): its Characteristics, Conditions, and Consequences, The Disaster Research Center, University of Delaware, Newark, 2011.
[4] A.V. Gampell, J.C. Gaillard, M. Parsons, K. Fisher, Beyond Stop Disasters 2.0: an agenda for exploring the contribution of video games to learning about disasters, Environ. Hazards 16 (2) (2017) 180–191.
[5] A. Solinska-Nowak, P. Magnuszewski, M. Curl, A. French, A. Keating, J. Mochizuki, W. Liu, R. Mechler, M. Kulakowska, L. Jarzabek, An overview of serious games for disaster risk management – prospects and limitations for informing actions to arrest increasing risk, International Journal of Disaster Risk Reduction 31 (2018) 1013–1029.
[6] E. MacDonald, V. Johnson, M. Gillies, D. Johnston, The impact of a museum-based hazard education program on students, teachers and parents, International Journal of Disaster Risk Reduction 21 (2017) 360–366.
[7] M. de Aguilera, A. Mendiz, Video games and education: (education in the face of a "parallel school"), Comput. Entertain. 1 (1) (2003) 1–14.
[8] M. Xanthoudaki, Museums, innovative pedagogies and the twenty-first century learner: a question of methodology, Mus. Soc. 13 (2) (2015) 247–265.
[9] N.B. Adams, Toward a model for knowledge development in virtual environments: strategies for student ownership, Int. J. Humanit. Soc. Sci. 2 (2) (2007) 71–77.
[10] M. Chau, A. Wong, M. Wang, S. Lai, K.W.Y. Chan, T.M.H. Li, D. Chu, I.K.W. Chan, W. Sung, Using 3D virtual environments to facilitate students in constructivist learning, Decis. Support Syst. 56 (2013) 115–121.
[11] E. Klopfer, J. Haas, S. Osterweil, L. Rosenheck, Resonant Games: Design Principles for Learning Games that Connect Hearts, Minds, and the Everyday, MIT Press, Cambridge, 2018.
[12] B.B. Ray, A. Powell, B. Jacobsen, Exploring preservice teacher perspectives on video games as learning tools, Journal of Digital Learning in Teacher Education 31 (1) (2014) 28–34.
[13] T. Brabazon, Museums and popular culture revisited: kevin Moore and the politics of pop, Mus. Manag. Curatorship 21 (2006) 283–301.
[14] I. Paliokas, S. Sylaiou, The use of serious games in museum visits and exhibitions: a systematic mapping study', in: Paper Presented at 8th International Conference on Games and Virtual Worlds for Serious Applications, Barcelona, September 7-9, 2016, 2016. https://www.researchgate.net/publication/304571734_The_Use_of_Serious_Games_in_Museum_Visits_and_Exhibitions_A_Systematic_Mapping_Study. accessed October 2018.
[15] N. Yiannoutsou, N. Avouris, Mobile games in museums: from learning through to game play to learning through game design, ICOM Education 23 (2012) 79–86.
[16] T. Naskali, J. Suominen, P. Saarikoski, The introduction of computer and video games in museums – experiences and possibilities, IFIP International Federation for Information Processing 416 (2013) 226–245.
[17] E. Delgado, Museums as spaces of negotiation, in: S. Bodo, K. Gibbs, M. Sani (Eds.), Museums as Places for Intercultural Dialogue: Selected Practices from Europe, MAP for ID Group, Europe, 2009, pp. 8–9.
[18] C.E. Demski, Museum Discovery Rooms Engaging Families Using Learning Theories, Master's thesis, Seton Hall University, 2009, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.470.6561&rep=rep1&type=pdf.
[19] A. Elwick, Understanding implicit learning in museums and galleries, Mus. Soc. 13 (4) (2015) 420–430.
[20] K.R. Jeffery-Clay, Constructivism in museums: how museums create meaningful learning environments, J. Mus. Educ. 23 (1) (1998) 3–7.
[21] A.F. Chow, K.C. Woodford, J. Maes, Deal or no deal: using games to improve student learning, retention and decision-making, Int. J. Math. Educ. Sci. Technol. 42 (2) (2011) 259–264.
[22] A.M. Cohen, The gamification of education, Futurist 45 (5) (2011) 16–17.
[23] G.E. Hein, Constructivist Learning Theory the Museum and the Needs of People, 1991. Retrieved from, https://www.exploratorium.edu/education/ifi/constructivist-learning.
[24] A. al Mahmud, Constructivism and reflectivism as the logical counterparts in TESOL: learning theory versus teaching methodology, TEFLIN Journal 24 (2) (2013) 237–257.
[25] D.H. Schunk, Constructivism, in: Learning Theories an Educational Perspective, Pearson Education, Boston, 2012, pp. 228–276.

[26] J.L. Meece, D.H. Daniels, Cognitive development: Piaget's and Vygotsky's theories, in: Child & Adolescent Development for Educators, McGraw-Hill Higher Education, New York, 2008, pp. 126–184.
[27] M. Cicconi, Vygotsky meets technology: a reinvention of collaboration in the early childhood mathematics classroom, Early Child. Educ. J. 42 (1) (2014) 57–65.
[28] D.J. Wood, J.S. Bruner, G. Ross, The role of tutoring in problem solving, J. Child Psychol. Psychiatry Allied Discip. 17 (2) (1976) 89–100.
[29] Earthquake Commission, About EQC, 2018. Retrieved from, https://www.eqc.govt.nz/about-eqc.
[30] Canterbury Museum, Quake City, 2019. Retrieved from, https://www.canterburymuseum.com/whats-on/quake-city/.
[31] D. Selby, F. Kagawa, Disaster Risk Reduction in School Curricula: Case Studies from Thirty Countries, UNICEF, Geneva, 2012.
[32] Etties, EQ-IQ/Quakehouse, Unpublished Report, M&C Saatchi, 2007.
[33] Museum of New Zealand Te Papa Tongarewa, Te Pūrongo Ā Tau Annual Report 2016/17, 2017 (Wellington).
[34] Canterbury Museum, Canterbury Museum Annual Report 2017/18, Canterbury Museum Trust Board, Christchurch, 2018.
[35] RiskRed, Stop Disasters Fire Scenario Report, 2007 (Unpublished report, RiskRed).
[36] Museums Aotearoa, A Strategy for the Museum Sector in New Zealand, The Museums of New Zealand, Wellington, 2005. Retrieved from, http://www.museumsaotearoa.org.nz/sites/default/files/strategy_1.pdf.
[37] A. Loparev, C.A. Egert, Scaffolding in educational video games: an approach to teaching collaborative support skills, in: Proceedings of the 45th Annual IEEE Frontiers in Education Conference, IEEE Publishing, 2015, pp. 891–895.
[38] M.F. Young, S. Slota, A.B. Cutter, G. Jalette, G. Mullin, B. Lai, Z. Simeoni, M. Tran, M. Yukhymenko, Our princess is in another castle: a review of trends in serious gaming for education, Rev. Educ. Res. 82 (1) (2012) 61–89.
[39] Sega Nerds, The Nostalgic Resurgence of Classic Video Games, 2019. Retrieved from, http://www.seganerds.com/2019/09/27/the-nostalgic-resurgence-of-classic-video-games/.
[40] G. Schmidt, The Future Is Bright for the Video Games of Yesterday, 2018. Retrieved from, https://www.nytimes.com/2018/12/02/business/retro-video-games.html.
[41] Dnz16, Digital New Zealand Report, 2016. Retrieved from, http://www.igea.net/wp-content/uploads/2015/09/Digital-New-Zealand-2016-DNZ16.pdf.
[42] G.E. Hein, Progressive education and museum education: anna billings gallup and louise connolly, J. Mus. Educ. 31 (3) (2006) 161–173.