Building a Digital Educational Escape Room Using an Online Design-Thinking Process

Jenny Moffett
Dara Cassidy
RCSI University of Medicine and Health Sciences, Ireland

Abstract
There is increasing interest in the application of game-based learning approaches to education. Educators across a wide range of contexts are using digital games such as educational escape rooms to promote learner motivation and support skills development. Whilst the literature describes multiple game-based learning theories that can underpin such strategies, there is little practical guidance on how to integrate such conceptual elements into the design of digital educational escape rooms. This study aims to address this gap, outlining the use of an online design-thinking process to plan, build, and test a digital educational escape room. Our findings suggest that this process provides an effective way of harnessing team collaboration and innovation in the development of digital educational resources. The process provides structure for game design teams, enabling them to address complex or "messy" educational development problems. In utilising an online design-thinking process to design games for learning, we make a number of recommendations. These include taking time to establish psychological safety within the design team so as to facilitate creative team processes and supporting team members to adopt a design-thinking mindset throughout (e.g., regularly taking the perspective of the game user, and testing game prototypes early and frequently). Finally, our study offers a detailed description of how the online design-thinking process can be applied in an education context with the aim of offering guidance to educators and students who may want to design, build, and test their own digital educational escape rooms.

Keywords: Design thinking, escape game, escape room, game-based learning, game design, online learning

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The use of games, specifically digital games, in educational contexts has been identified as an important emerging trend (Martin et al., 2020; Park & Shea, 2020). Game-based learning is increasingly used to promote learner motivation and improve the quality of the learning experience for students in a wide range of contexts, including online settings (An & Bonk, 2009; Moreno-Ger et al., 2008; Prensky, 2007). Game-based learning can involve students in game-making as well as game-play, and an increasing body of research focuses on the capacity of game design to support higher order learning such as creativity and critical thinking (Hayes & Games, 2008; Moreno-Ger et al., 2008).

Despite the growing evidence base behind game-based learning, it can be difficult for online educators to incorporate such approaches into their teaching. Whilst educators may be aware of the wide variety of educational theories relating to game-based learning (De Freitas, 2006; Plass et al., 2015; Steinkuehler & Tsaasan, 2020), they often lack clear guidance on how to apply such conceptual elements in designing online educational games. Furthermore, there are few frameworks or models that support educators to use game design in online learning contexts (Weitze, 2021).

To address this gap in the literature, our study explores the use of an online design-thinking process to design, build, and test a type of digital game known as an educational escape room. To the authors' knowledge, this is the first study that examines the development of an educational escape room using design-thinking methods mediated entirely within an online environment. First, our article offers a review of the literature relevant to online education, game-based learning, digital educational escape games, and developing educational games using design thinking, followed by details of our research questions. Second, we present a detailed description of our study design and, in particular, the online design-thinking methodology that was used. Third, we present the results of testing an initial digital educational escape room prototype. Fourth, we discuss these results alongside the applications of online design thinking for building digital games.

Review of Related Literature

Online Education

The fostering of interaction and communication within learning communities is a foundational concern of online education (Conrad, 2014). From its roots in distance education, the theory of transactional distance (Moore, 1993) captured the "psychological and communication space" that emerges between teacher and learners (Giossos et al., 2009, p. 2), when they are separated physically and sometimes temporally. High levels of transactional distance require learners to exercise greater levels of autonomy in order to succeed, while learning environments that facilitate a high level of dialogue (constructive interaction) between teacher and learner serve to decrease the transactional distance (Moore, 1993). Although the theory has been criticised for its failure to operationalise the key constructs (Ekwunife-Orakwue & Teng, 2014; Gorsky & Caspi, 2005), the notion of transactional distance is still recognised as an analytical framework that can be used to understand the dynamics of online distance education systems (Gorsky & Caspi, 2005).

The Community of Inquiry (COI) (Garrison et al., 2010) focuses on the elements that support the development of a collaborative online learning environment, and is a well-researched, empirically tested framework within which to plan and research online education (Stenbom, 2018). The COI focuses on three types of presence that have been shown to be critical in online education—social, teacher and cognitive. Social presence refers to individuals' ability

to project themselves as real people, and thus provide a basis for meaningful interpersonal interaction in the virtual world. Teaching presence refers to the actions an instructor takes to guide students along their learning journey (e.g., through dimensions of instructional design). Cognitive presence relates to the extent to which the participants in a learning community are able to construct meaning through sustained communication. It is the goal toward which social and teaching presence are directed, and a manifestation of higher-order learning in the online environment (Moore & Miller, 2022).

The COI emerged at a time where interaction within the community of learners was largely asynchronous. However, more recently, the widespread adoption of video conferencing platforms has opened new avenues for synchronous online engagement as a central modality (Watts, 2016). It has been suggested that synchronous formats may be more suited to socialising and engaging in less complex tasks and planning activities (Hrastinski, 2008; Watts, 2016), while asynchronous modes are better suited to more challenging group activities that require reflection (Hrastinski, 2008; Mabrito, 2006; Watts, 2016). However, media-rich synchronous environments can be used to facilitate deep learning (Overbaugh & Casiello, 2008; Strang, 2013). Online educators are advised to factor in the subject matter, learning outcomes, and learner characteristics when seeking to determine the appropriate mix of synchronous and asynchronous activities (Watt, 2016).

Game-Based Learning

Game-based learning can be defined as "an environment where game content and game play enhance knowledge and skills acquisition, and where game activities involve problem-solving spaces and challenges that provide players/learners with a sense of achievement" (Qian & Clark, 2016, p. 51). In recent years, the growing acceptance of digital games as mainstream entertainment (McClarty et al., 2012; Plass et al., 2015) coupled with an increasing focus within education on transversal skills has led to an enhanced interest in the application of game-based learning approaches in education (Taraldsen et al., 2020). A growing number of studies highlight the capacity of digital games to promote motivation and engagement; facilitate learner-centred feedback; provide opportunities for role play, practice and rehearsal of skills; and foster collaboration, problem solving, and critical thinking (Anderson, 2008; Gros, 2015; Martin et al., 2020).

Digital games are particularly suited to online learning settings. Effective online learning is interactive, flexible, and facilitates connections between educators and peers (Moore et al., 2011). Digital games for learning, if designed well and applied appropriately, can uphold many of these characteristics. Furthermore, games which harness social-constructivist or constructionist learning theories can help meet some of the challenges encountered in online learning environments (e.g., student isolation and lack of engagement) (Hu & Li, 2017; McInnerney & Roberts, 2004). Game-based learning can be employed at multiple different levels, and there is a growing recognition of the value of involving students in the design of educational games (Gros, 2015; Prensky, 2008). Through learning by doing, game design offers students routes to deep learning, and opportunities to engage with authentic problem-solving and creative processes (Prensky, 2008; Qian & Clark, 2016; Vos et al., 2011).

Digital Educational Escape Rooms

Educational escape games, also known as escape rooms or breakout games, are an increasingly common way for educators and students to engage with game-making (Whitton,

2018). Originating from the entertainment industry, escape games can be defined as a "live-action, team-based game where players discover clues, solve puzzles, and accomplish tasks in one or more rooms in order to accomplish a specific goal… in a limited amount of time" (Nicholson, 2015, p. 1). When used for educational purposes, the escape game goals are aligned with learning outcomes for players.

In recent years educational escape games have transitioned into online settings, and are often referred to as digital educational escape rooms (DEERs). DEERs are used in a wide range of settings to address many, varied learning outcomes (Doroudian et al., 2017; Huang et al., 2020), and have proved a popular way of facilitating active and team-based learning during the Covid-19 pandemic (Cates et al., 2020; Ross et al., 2021). In the literature, DEERs have been linked to different educational theories including cognitivist, constructivist, and socio-cultural approaches to learning (Makri et al., 2021; Taraldsen et al., 2020). Although research in this domain is in its infancy, escape games are thought to support the acquisition of knowledge, as well as the development of team-building, problem-solving, and communication skills (Makri et al., 2021).

Developing Educational Games Using Design Thinking

Digital games such as educational escape rooms offer opportunities to improve the quality of online learning experiences (Moreno-Ger, 2008). However, their incorporation into learning environments requires a thoughtful, theory-based approach that reflects the often complex cognitive, emotional, and motivational mechanisms involved (Krath et al., 2021). Educators must understand the variety of pedagogical and game design considerations involved in building engaging game-based environments (Veldkamp et al., 2020). Support and guidance is necessary when integrating game-based learning in online environments (Gros, 2015).

Design thinking offers an established framework for building digital games for learning (Hayes & Games, 2008). Defined as a "way of finding human needs and creating new solutions using the tools and mindsets of design practitioners" (Kelley & Kelley, 2013, p. 24-25), design thinking offers a structured process for teams to engage in collaborative, creative work (Kimbell, 2011). In recent years, the approach has been used extensively in the development of educational escape rooms, both physical (Eukel & Morrell, 2021; Martens & Crawford, 2019; Zhang et al., 2020) and digital (Cordova-Rangel & Caro, 2021; Vold et al., 2021). Design thinking may hold particular value for online educators as the process can be mediated entirely within virtual settings (Alnusairat et al., 2020; Zeivots et al., 2021). Online design thinking has emerged rapidly across a wide range of online learning environments and contexts (Conrad & Farao, 2020; Zeivots et al., 2021).

However, surprisingly few studies explore the use of online design thinking in the development of digital games for learning. Whilst the literature provides several examples of the use of face-to-face design thinking to build *physical* educational escape rooms (Eukel & Morrell, 2021; Martens & Crawford, 2019), there are none, to the authors' knowledge, which examine the use of online design thinking to build *digital* educational escape rooms. This represents an important knowledge gap for online educators, and one that our study seeks to address. Thus, our research questions are:

1. How can an online design-thinking process be used to design, build, and test a digital educational escape room?
2. What are users' experiences of a prototype digital educational escape room developed using online design thinking?

Methods

This study forms part of a larger design-based research project that aims to explore how medical students can be supported to manage uncertainty during their undergraduate education. Design-based research offers a flexible approach which allows researchers to design and test educational resources in a naturalistic settings, whilst simultaneously advancing our understanding of relevant theoretical frameworks (Barab & Squire, 2004). Design-based research projects can be organised broadly according to three phases: preliminary research, prototyping, and assessment and reflection (Plomp, 2009). This study focuses on the prototyping phase, specifically the first design cycle of the project and a small-scale usability study. The study employed qualitative data collection and thematic analysis methods in order to uncover rich contextual data around the game users' experiences (Kriz & Hense, 2006).

Context

In 2021, researchers at RCSI University of Medicine and Health Sciences received funding to design, build, and test a digital educational escape room that aimed to help medical students to manage uncertainty. The focus of the escape room was on supporting students during transitions from pre-clinical, college-based work to clinical placements in hospital settings, an experience that is frequently recognised as stressful and anxiety-provoking (Brennan et al., 2010). A design team was enlisted to build the escape room, and medical students at RCSI, a culturally diverse, international health sciences university with over 4,000 students from 90 different countries, were invited to take part. The core team consisted of ten medical students (six female undergraduate medicine students; three male undergraduate medicine students; one female graduate-entry student) and one educationalist based in the university's faculty learning and development unit. Team members joined from five different countries across three continents.

Intervention

We used an online design-thinking intervention to design, build, and test our digital educational escape room. This intervention followed the five-phase process of design thinking proposed by the Hasso Plattner Institute of Design at Stanford University (d.school, 2019): empathise, define, ideate, prototype, and test. The project ran over a nine-week period in the summer of 2021, and, during this time, a further 26 medical students, two educational escape room researchers, three medical education professionals, two design professionals, two illustrators, one medical uncertainty researcher, and an audio-visual professional were invited to contribute.

Prior to commencement of the design-thinking process, the lead researcher [JM] developed a high level brief for the project, which delineated how it was intended to support attainment of specific learning outcomes. Informed by socio-cultural theories of how learners engage with and support each other, the educational goal of the escape room was to introduce the topic of uncertainty in healthcare and create conditions that would enable game users to experience uncertainty and explore the processes by which they supported each other as they

progressed through the game. Subsequent to completion of the game, a debriefing session would be used to trigger reflection and offer theoretical inputs to scaffold learners' ability to manage feelings of uncertainty.

The lead researcher created a purpose-built online space that was housed on a Moodle virtual learning platform (Moodle HQ; Perth, Australia). This online environment held details of the project schedule, project aims, online meeting links, weekly activities, team contact details, and acted as a repository for collaborative teamwork and project documentation. Online teamwork and communication was facilitated by several technologies including Zoom (San José, USA), Miro (San Francisco, USA), Padlet (San Francisco, USA), and WhatsApp (Meta; San Francisco, USA). Prior to initiation of the design-thinking process, a series of online activities (e.g., ice-breakers, discussion, and games) were held so as to establish psychological safety and a design-thinking mindset within the group. During these opening online meetings, the team discussed the project design challenge: How might we use a digital educational escape room to help medical students manage uncertainty during transitions into the clinical setting? Overall, we aimed to create an online educational resource that would help medical students to manage uncertainty, with a timeline of nine weeks and a budget of €2,000 to create a prototype.

Empathise

The aim of the first phase of design thinking is the development of a deep understanding of the design challenge and whom it affects. During early discussions, the team identified activities and people that could help them to build insight. We carried out a review of the academic literature with a specific focus on uncertainty and medical students, medical students' experiences of transitions from pre-clinical to clinical environments, and educational escape rooms. We also invited content experts to team meetings to further probe these research domains. As a result, we identified gaps in our knowledge such as, "How might an escape game help users to better manage uncertainty?"; "Is it important or useful for users to experience uncertainty during game-play?"; and "How can the game provide education as well as entertainment?" The team also engaged in discussions which aimed to define our audience for the escape room (i.e., the game users). The audience was primarily defined as pre-clinical medical students, although other relevant stakeholders were identified including clinical medical students, clinical educators, and patients. We spent time reflecting on the diverse nature of medical student cohorts with different socio-cultural and language backgrounds, and varying degrees of interest in, and confidence with, technology-enhanced learning.

We then explored game users' perspectives through a series of empathy interviews. Empathy interviews are a common design-thinking activity which aim to help design teams find out as much as possible about the user's experience with respect to a problem, process, or context. To complete this task, the design team co-constructed a question guide and used this to interview medical students who had recently transitioned from pre-clinical to clinical education. The design team set out to learn more about the students' experiences, address knowledge gaps, and invite advice as to how a DEER may be of value in the context of clinical transitions. The empathise stage of design thinking also invites teams to immerse themselves in the problem and gain inspiration through carrying out fieldwork or observations. To do this, our design team played a variety of online escape games that ranged from simple, online educational games (VetKind, 2020), through to more sophisticated commercial games (Escape Experience Chattanooga, 2021; Experios, 2021).

Define

The second phase of design thinking involves transforming information gathered during the empathise phase into meaningful insights. To do this, the design team engaged in a series of individual and group reflections that included an affinity mapping exercise, a design activity which helps teams to organise large volumes of mixed data into themes or clusters. This activity helped the team to identify themes and scenarios around uncertainty that had emerged from interviews and could be suitable for prototyping. The affinity map was constructed using a mind-mapping software (Miro.com; San Francisco, USA) and resulted in a persistent artefact that could be re-visited at any stage of the project.

The define stage of design thinking also asks teams to reflect on further "How might we…?" questions. In our project, questions that emerged included "How might we make a game that addresses the needs of undergraduate medical students whatever their background and culture?" and "How can our game be made accessible regardless of the user's experience or confidence with digital learning technologies?" During the define stage, the team proposed a list of draft educational learning outcomes for the DEER, and a set of design principles that could influence design of the game. With respect to the latter, we considered that DEERs that aim to support learning around uncertainty could benefit from:

- An engaging and consistent storyline
- Game goals that align with intended learning outcomes
- Gameplay which supports authentic shared reflection
- Contextualisation of gameplay with appropriate pre-briefing and de-briefing
- Game flow which involves an easy puzzle ("quick win") at the start
- Puzzles that trigger affective experiences of uncertainty for players

Finally, we explored a range of pedagogical theories and strategies that could inform how learning might take place for the game users, including social constructivism, shared reflection, and the Community of Inquiry framework (Garrison et al., 2010).

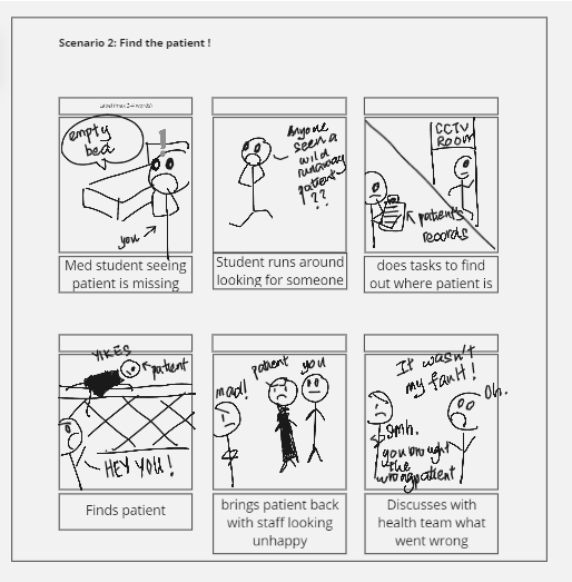
Ideate

During the ideate phase, design teams generate and refine ideas that may be relevant to the design challenge. To do this, our team engaged in separate stages of divergent (coming up with as many ideas as possible) and convergent (ranking, sorting, or narrowing ideas down) thinking. We generated and refined ideas with respect to multiple different game elements, including the narrative, game-flow, and puzzles, using an escape game design framework (Botturi & Babazadeh, 2020).

In devising a DEER theme, the design team broke into small groups and were asked to create a vision board using images that represented the "look and feel" of a DEER that would align with medical students' experiences of uncertainty. The vision boards were created using Padlet (San Francisco, USA) and the teams presented these to each other for feedback and discussion. Then, between sessions, team members were asked to reflect on the discussions and submit ideas for themes anonymously through a shared online document (Google Docs; Alphabet; Palo Alto, USA). At the next session, the design team reviewed the themes and ranked them in order of preference. The team was subdivided into small groups and asked to advance ideas for the two top themes. This was achieved through a storyboarding exercise, facilitated through Miro.com (San Francisco, USA) (Figure 1). The team discussed the different

storyboards, and key ideas from each were synthesised into a draft DEER narrative. This draft narrative was shared with team members who were invited to add and make changes to the story.

Figure 1
Detail from Storyboarding Exercise



In developing puzzles, design team members were assigned to the game learning outcomes using an educational blueprint. Each team member created one or more puzzles and used a reflective template to outline puzzle features (i.e., puzzle type, difficulty, game outcomes, and hint and reward strategies) (Appendix A). Team members then play-tested and gave feedback on each other's puzzles. The team selected the puzzles that they felt were most engaging and aligned best with the DEER learning outcomes. The design team then split into small groups and advanced the chosen puzzles. Finally, the design team play-tested this iteration of puzzles.

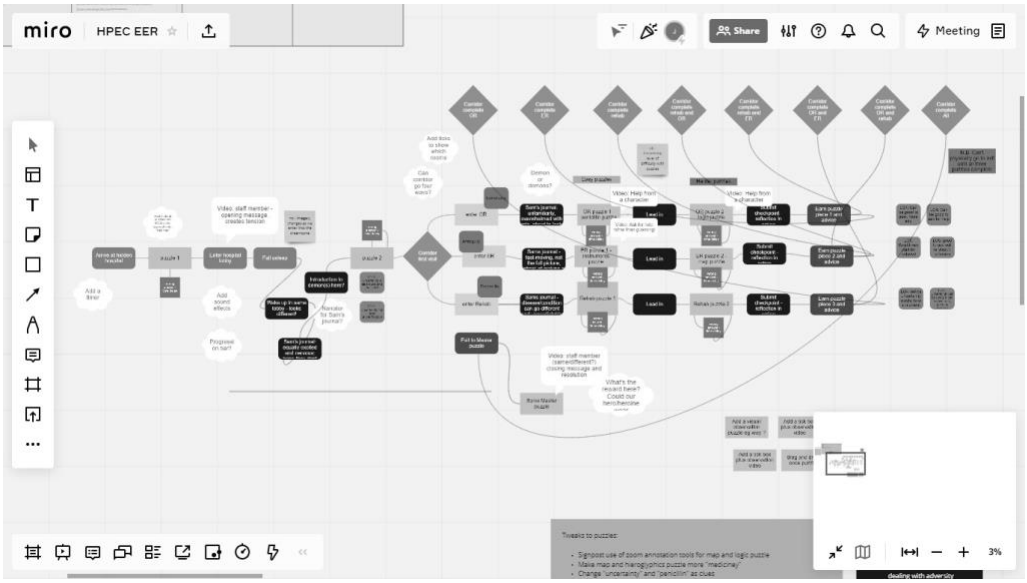
Prototype

Design thinking is a bias towards action over discussion (i.e., ideas are tested early and frequently through the creation of prototypes). Storyboards and models allow the design team to explore how well, and in what way, their efforts address the design challenge. To test our initial concept, the design team built a prototype DEER on an online interactive content editor platform (Genially; Madrid, Spain). Puzzles were selected and placed in sequence on the platform. The final puzzle selection was cross-checked with the educational blueprint, ensuring that the game learning outcomes were addressed. A puzzle flow chart was created to provide a visual overview of the prototype and the game users' pathway (Figure 2). Finally, the team decided on topics to address during the pre-brief and de-brief aspects of the game-play session.

The resulting prototype consisted of a 10-puzzle game built on the Genially platform. The overall theme for the game was that of a clinical medical student navigating through a creepy, dream-like hospital setting, and a basic storyline was presented through a game character's reflective journal. The puzzle structure was branched or path-based (Nicholson, 2015), and involved a variety of puzzles, including numerical, word-based, logic, and general knowledge.

Each puzzle had an associated hint. This prototype was designed to be used by small groups of players (4-6), who would work collaboratively in online break-out rooms to solve puzzles and earn clues towards a final meta-puzzle. The prototype lacked a developed storyline or sophisticated audio-visual content.

Figure 2
Puzzle Flow Chart



Test

The testing phase of design thinking asks users to engage with a prototype and elicits their feedback. The aim is to find out what works and why at an early stage of the process, and most design-thinking processes involve multiple stages of testing and refinement. In our project, the testing phase represented a small-scale usability study which aimed to explore game users' experiences of the Genially platform and the puzzles (e.g., quality, difficulty, and overall flow). Details of the testing stage are provided below.

Participants

All medical students enrolled at the university were eligible to take part in testing, and recruitment took place through online, student-led social media channels. In addition, content experts who had taken part in the scoping aspect of the design-based research project were invited to test the prototype. Participants were arranged into play-test groups. There were no specific exclusion criteria, and no incentives were offered to take part in the study.

Data Collection and Analysis

In July 2021 the prototype escape room was play-tested with participants. There were two methods of data collection. First, the participants were arranged into small groups of 4-5, and asked to play the prototype game using a concurrent think-aloud protocol (Ericsson & Simon, 1983; McDonald et al., 2012). In accordance with this method, participants were asked to

describe their experiences verbally as they interacted with the game (Ericsson & Simon, 1998). Game-play took place following a short pre-brief (5 minutes) and was followed by a de-brief (15 minutes). During each play-test session a facilitator was present; the facilitator's role was to remind the participants of the think-aloud process and offer help if game-play stalled. The play-test facilitators also collected field notes that captured written observations of the users' interactions with the game.

Second, participants were invited to share their opinions on their game-play experiences in focus group discussions that took place immediately after play-testing. Focus groups were facilitated by experienced researchers, and the question guide sought the participants' experiences of the game itself, the puzzles, and their learning around uncertainty. Participants were also given the opportunity to provide advice to improve the prototype.

Both the think-aloud sessions and focus groups were facilitated through Zoom web-conferencing software (San José, USA). All sessions were video-recorded, and the audio component of each was transcribed by JM. Qualitative data from both the play-test sessions and the focus group discussion were combined and explored using reflexive thematic analysis (Braun & Clarke, 2013). The researchers used an inductive approach to identify codes and themes within the data. The transcriptions were read and re-read several times, and any comments that related to the research questions were noted, resulting in a set of opening codes. These codes were then organised into initial themes. As analysis continued, these themes were refined, re-organised and then allocated a name. The results of this thematic analysis are presented below.

Results

Participants

Seventeen students (11 female undergraduate medical students, three male undergraduate medical students, three female graduate entry medical students) agreed to test the prototype and were assigned to four play-test groups. Five content experts (two female escape room researchers, one male game-based learning researcher, one female uncertainty researcher, one male uncertainty researcher) also agreed to take part and were assigned to two further groups.

The following research questions guided researcher engagement:

Research Question 1: How can an online design-thinking process be used to design, build and test a digital educational escape room?

The results of this study suggest that online design thinking offers an effective approach in the development of digital educational escape rooms. Here, the online design-thinking process resulted in a 10-puzzle game built on a Genially (Madrid, Spain) platform, which was play-tested by six groups of users. All groups reported that the game functioned well, and the platform was deemed easy-to-use and intuitive by the users. All groups were able to progress through the game, although only four out of the six groups completed the escape room within the allocated time. For the groups that did finish, the average duration of play was 59 minutes, with a range of 49 minutes to 1 hour nine minutes.

Research Question 2. What are users' experiences of a prototype digital educational escape room developed using online design thinking?

Four major themes emerged from the qualitative data analysis: (1) positive aspects of the prototype, (2) negative aspects of the prototype, (3) support of learning, and (4) suggestions for improvement.

Positive Aspects of the Prototype

Overall, the game users reported many positives about the prototype game and highlighted that it was a fun experience. The main aspects of the game that they enjoyed were working as a team and engaging in challenging puzzles. Game users were also positive about the theme of the escape room, and that it presented a "good representation" of experiences of medical students on clinical placements. They also liked the "feel" of the game, the "creativity" of the storyline, and found the artwork attractive and professional. With regards to the puzzles, game users reported that there was a good variety and mix of difficulty levels. They liked certain aspects of puzzle sequencing; for example, the users appreciated an opening puzzle that was relatively easy. Finally, the game users were largely positive about the Genially platform. They reported that it was intuitive, easy-to-use and, overall, supported teamwork during the game.

Negative Aspects of the Prototype

Game users also identified several negative aspects of the prototype. For example, there were a range of technical issues such as puzzles glitches, spelling errors, and broken links which they considered had interrupted the "immersivity" of the experience. With regards to puzzles, two were thought to be "under-challenging" with "predictable answers." It was also considered that there were too many word-based puzzles (e.g., anagrams), and that such puzzles could be especially challenging for non-native English speakers. Game users also suggested that the platform could be more interactive and use more sophisticated game elements (e.g., addition of augmented or virtual reality).

Support of Learning

With regards to learning around uncertainty, users reported that there were moments within game-play that they felt "helpless" and "uncertain," and agreed that the game-play effectively provoked these affective experiences. For some, game-play facilitated insights such as "going with your gut," "being comfortable with being uncomfortable," and "it's good to share." Other users reported that they had failed to learn about uncertainty during game-play. They made recommendations that the game would benefit from stronger links between puzzle content and the evidence base around uncertainty.

With regards to other learning outcomes, the users reported that the prototype had supported them to engage in critical thinking. They considered that the game provided them with a "safe" environment to test ideas and engage in shared reflection. Multiple users mentioned that the game had helped them to appreciate the different strengths, skills, and perspectives of others.

Suggestions for Improvement

Users also made suggestions for improvement of the escape room. With regards to puzzle design, they thought that there should be fewer word-based and general knowledge puzzles, and more visual or pattern-based ones. Clearer instructions should also be added to some puzzles. Several extra features were suggested including a progress bar, timer, and "scratch pad" to capture written team-work. Participants also thought that a different game strategy (e.g., time penalties or supplementary puzzles for incorrect answers) might help reduce the motivation for

users to engage in guessing behaviour. Successful solving of each clue, and of the game overall, could be linked to a more explicit reward, for example, a message of gratitude from a patient. Game users also offered ways to improve the pre-brief (e.g., providing greater guidance over team roles as well as rules around using the internet to solve puzzles). Finally, game users expressed a preference for a richer audio-visual experience (i.e., improved graphics and the addition of videos and a soundtrack.)

Written Observations

During play-testing, facilitators collected field notes. According to these written observations, all groups were able to progress through the game. Overall, the Genially platform functioned as expected and the users were able to click through puzzles and content with ease. There were, however, some issues that emerged during game play. For example, the hint strategy was not used by players as intended. Hints were provided to the game users through a map feature. Many groups failed to notice the map and, for others, its purpose was not clear and appeared to cause confusion. Furthermore, the groups that were aware of a hint strategy seemed reluctant to use this function; it is possible the presence of a facilitator during game-play may have had a negative influence on the game users' decisions to use the hint strategy, or to engage in guessing behaviour.

Discussion

Our study set out to explore the use of an online design-thinking process to design, build, and test a digital educational escape room. The results of our first design cycle suggest that the online design-thinking framework supported the creation of a functional prototype educational escape room which was well-accepted by users. Overall, game users were positive about key game elements such as the platform and puzzles, and they commonly reported experiences of fun and enjoyment during gameplay. In addition, the users identified ways in which game-play had supported their learning around uncertainty through both cognitive and affective mechanisms, as well as the value of the game in promoting a "safe" space for teamwork. The users also offered guidance around how to advance the platform, puzzles, and other game elements which can be fed into further design cycles and iterations of the game. In addition, the study results appear to substantiate our initial digital educational escape room design principles.

Whilst our study aimed to evaluate the *product* of online design thinking, an educational escape room, our findings also offer insight as to the *process* of online design thinking and how it can be used to develop games for learning in online settings. Designing games and integrating these into online learning environments can be a "laborious and complex process" (Berg Marklund & Alklind Taylor, 2015, p. 367). When the development process itself is taking place in a technology-mediated context, a complex range of factors need to be considered to provide a holistic insight into the dynamics involved (Bower, 2019). A strength of online design thinking is its capacity to structure such processes, helping game development teams to organise their activities and methods. Moreover, this approach promoted a high degree of dialogue and reduced the transactional distance (Moore, 1993) between students who were grappling with unfamiliar technologies and activities. Design thinking also appears to have helped to facilitate the development of an online community that in many ways mirrored a community of inquiry (Garrison et al., 2010) with the aspects of social, teaching, and cognitive presence clearly evident. Within this community, the educator could scaffold the overall learning experience for the students (i.e., teaching presence) who had little background experience of game design or

game-based learning. Scaffolding has been shown to be particularly important in online learning environments, and educators are advised to reflect on students' needs, and to use appropriate, supportive learning resources and instructional methods (Jumaat & Tasir, 2014).

Furthermore, online design thinking facilitated the creation of a structured blend of synchronous and asynchronous activities (Watts, 2016), with synchronous meetings used to brainstorm and exchange ideas supported by the use of collaborative white board (Duncan et al., 2012; Hrastinski, 2008; Rockinson-Szapkiw & Wendt, 2015), and the asynchronous Moodle virtual learning environment configured to support aspects of the projects that required deeper discussion and reflection (Hrastinski, 2008; Mabrito, 2006). This approach to online communication during the project seemed to facilitate team formation and break down perceived power hierarchies. This supports the notion that students' ideas can attain "greater equality, exposure and consideration" when online design-thinking processes are compared to those that take place in physical design studios (Griffen, 2016, p. 30). The project also cultivated a sense of connection and camaraderie within the team (i.e., social presence) against the backdrop of a particularly difficult year defined by Covid-19 lockdowns and restrictions. Overall, these conditions supported our educator-student team to work together in a genuinely collaborative manner, overcome geographical distance, and to engage effectively with a "messy" design challenge.

Our experiences of online design thinking suggest that this approach offers a unique environment for testing educational games in naturalistic online settings. With its emphasis on human-centredness, design thinking keeps the needs of the user in the foreground as ideas and solutions are generated. Online design thinking, by its very nature, also keeps issues of technology and how learners operate in online settings in sharp focus. It appears that an online environment can offer more insight as to how a target audience may use a digital educational game, as compared to a face-to-face environment. This human-centred approach also meant that the design team engaged in critical thought around how the game could be designed to meet the needs of diverse students from different cultures, backgrounds, and familiarity with digital games for learning. When combined with frequent periods of prototyping and testing, this process led to a digital game that worked well in an authentic online learning setting and was well-received by its target audience.

Online design thinking is not, however, without its challenges. The process is time-consuming and resource heavy. Design teams need to harness expertise from a wide range of disciplines and backgrounds. In addition, careful team facilitation is required. Engaging in creative teamwork can be demanding, especially in online settings where nonverbal interpersonal communication is more restricted and where team members often connect across socio-cultural, language, and time zone barriers. Online design educationalists have noted that design teams' social interactions can be harder to facilitate in online settings (Fleischmann, 2021). It is thus necessary to have design team leads who can generate a learning environment that supports effective communication and encourages individuals to share ideas and offer authentic feedback to each other. Finally, although design thinking can take place on minimal budgets, the process does benefit from some degree of funding. Here, our budget allowed us the freedom to explore different avenues (e.g., test out different escape games, enlist the help of graphic designers, and experiment with different technologies).

Strengths and Limitations

To our knowledge, this is the first study that explores the use of an online design-thinking process in developing a digital educational escape room. The process can provide insight to educators that would like to use this approach in their own teaching context. However, there are limitations to this study. It should be noted that our student design team had self-selected to take part in the study; thus they were likely highly motivated to take part in the online design-thinking process. Research suggests that students often engage with collaborative online learning interventions to different degrees; some students find it harder to connect online, share ideas, and engage in deep dialogues than others (Thomas & MacGregor, 2005). Our findings may have been different if a wider cohort of students, with varying levels of engagement, had participated. Furthermore, design thinking is a context-specific activity and, as such, further studies that examine its use in designing different types of digital games, in multiple and varied online settings, would be valuable.

Conclusion

This study set out to explore the use of online design thinking as a model to support educators in harnessing game-based learning and game design in their online learning programmes. In doing so, it viewed the challenge of creating an online design-thinking process in terms of a teaching and learning challenge, mindful of the complex web of elements that require consideration in technology-mediated learning contexts (Bower, 2019). Overall, it was deemed that the design-thinking process worked well in the online setting. The approach proved an effective way of harnessing team collaboration and innovation within a geographically dispersed educator-student team, enabling them to address a "messy" educational development problem. Insights from this study may be helpful for educators, researchers or practitioners who want to use similar methodological approaches and co-create digital educational games with their students. In conclusion, we recommend the online design-thinking process as a strategy to design, build, and test online games for learning such as digital educational escape rooms.

Declarations

The authors declare that there are no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Appendix A

Puzzle Reflection Template

Learning outcome: What content is covered?	
Learning outcome: What do you want our gamer to know/do/feel/understand?	
What type of puzzle is this?	
What is the solution?	
What is the reward for getting the solution right?	
What effect does solving this clue have?	
What does the gamer need to do to reach the solution?	
What do we need to create for the gamer to reach the solution?	
What hint might you give to the gamer that gets stuck?	
Overall level of difficulty (tick one)	Easy Moderate Difficult
What else would you like to say about this puzzle?	