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Immersive virtual reality game for cognitive-empathy education: Implementation and formative evaluation

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Abstract

Empathy is an essential human skill that can be divided into two types: (i) cognitive empathy, which is the capacity of understanding others' thoughts and emotions; and (ii) affective empathy, which is the capacity to feel others' emotional states. Many educational contents exist for both types, and immersive virtual reality (VR) has been shown to be effective for empathy education. However, there is a lack of educational content on recognizing and accepting that people can have different perspectives and feelings in the same situation, which is a prerequisite for cognitive empathy. To this end, we developed an immersive VR game "Mysterious Museum" where the player solves various puzzles based on ambiguous images and three-dimensional models. Moreover, we implemented six versions of a level in the game based on design concepts for camera perspective (combinations of first-person and third-person with camera techniques) and content exhibition (gallery, conveyor belt). We then conducted a mixed-method formative evaluation with 19 participants (11 females, eight males, average age 25.4 years) measuring usability of the game, as well as cybersickness and preferences for the design concepts. The game's usability was satisfactory except for the quality of instructions. Moreover, the conveyor belt, where the player does not need to move, was preferred over the gallery, while the fixed first-person perspective was the most preferred camera perspective. The latter along with the conveyor belt exhibition method caused the least cybersickness. These results can be useful to designers, developers, researchers, and psychologists interested in VR-based empathy education.

Keywords Virtual reality · Game · Cognitive empathy · Empathy education · User experience · Cybersickness

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1 Introduction

Empathy is the ability to think or understand from the other person's point of view and is broadly classified into cognitive and affective empathy. Cognitive empathy is defined as "the ability to understand the thoughts, perspectives, and emotions of others" (Ghim et al., 2013). It is therefore about a person cognitively understanding another person's emotions and situation, even if they feel differently. In contrast, affective empathy is the capacity to feel another person's emotional state (Blair, 2005). Empathy is one of the fundamental skills of human beings that make us capable of social interactions and understanding one another (Reniers et al., 2011). Therefore, a considerable amount of effort has been devoted to developing education materials to improve one's cognitive and/or affective empathy.

In the field of traditional psychology`, many scholars have attempted to increase empathy levels by teaching individuals to recognize their own emotions and emotions in others, to take the perspectives of others, and express empathy in various situations. According to the review of Lam et al. (2011), the most common teaching methods are experiential training (e.g., role-play), didactic training (lecture-based), skills training (demonstration and practice), mindfulness training (teaching individuals to focus on their awareness in the present moment while calmly accepting their feelings, thoughts, and bodily sensations), and mixed methods. In particular, teaching cognitive empathy involves improving perspective-taking skills that help individuals imaginatively put themselves in the place of others, see situations through their eyes, and accurately sense what they might be thinking and feeling. In contrast, the affective components in empathy training encourage individuals to experience the emotions of someone else under specific circumstances (Chen-Bouck et al., 2021).

The current study is a part of the Virtual Human Experience (VHEX) project, funded by the Korea Radio Promotion Association, that aims to develop methods and technologies for diagnosing users' empathy types and train their empathy skills accordingly. Although the project addresses both cognitive and affective empathy, this study focuses on cognitive-empathy education, and more specifically on recognizing the need for cognitive-empathy education through recognizing and accepting that people can have different perspectives. This is referred to as self-other differentiation and it has been shown to have several positive effects on empathy (Coplan, 2004). However, previous studies of empathy education through gamification have mostly focused on scenario-based content where the user is observing, participating in, or role-playing a social situation that involves emotions (Chen et al., 2018; Kim, 2005; Peck et al., 2013; Poskiparta et al., 2012). While such scenario-based approaches are certainly beneficial for cognitive-empathy education, they do not cover the foundation of self-other differentiation through exercises that help the learner recognize and accept different perspectives.

To fill this gap in previous research, we aimed at creating a motivational cognitive-empathy education tool that could interest and engage the players. Virtual reality (VR) can provide a high level of immersion and user engagement, so we set out to develop a VR game that was considered suitable for the project. Previous research has shown that VR games can be an effective method of empathy education (Herrera et al., 2018; Muravevskaia, 2017; Tong et al., 2020). Moreover, Tong et al. (2020) showed that VR's affordances on immersion and embodiment play an important role in empathy, thus making VR technology potentially effective for empathy education. As the first objective of this study, we present a novel educational VR game Mysterious Museum for cognitive-empathy education with the core idea of expressing the need to understand various perspectives through ambiguous two-dimensional (2D) images and three-dimensional (3D) models. Ambiguous 2D images can capture various meanings in a single image. Different people may see different content in the image at first, and they may observe other content over time. Therefore, the same image can be viewed from different perspectives depending on the person. This game concept is motivated by the pedagogical approach to Visual Thinking Strategies that promotes multiple interpretations of visual content (Reilly et al., 2005). Similarly, ambiguous 3D models present different shapes depending on the observation angle. These ambiguous 2D and 3D visual contents aim to inform the player that different people can see and feel differently in the same situation. In this process, the need to understand other people's emotions is felt by promoting the player's recognition that other people may see or feel differently from the player. In addition, the second objective is to compare various content exhibition methods and camera perspective methods by conducting a formative evaluation with people with different degrees of VR experience. Through doing so, we seek to find the most appropriate methods for content exhibition and camera perspective for educational VR content. The results of our study on the development of Mysterious Museum for empathy education and its formative evaluation regarding design concepts can be useful when designing future game-based VR experiences for empathy education. However, this study does not measure empathy development with the game nor the relationship between learning empathy and the design concepts on content exhibition and camera perspectives.

2 Background

2.1 Empathy types and education

In general, empathy has been conceptualized as a bi-dimensional construct: cognitive and affective. Cognitive empathy, known as the theory of mind and perspective-taking, is an individual's capacity to understand others' emotions and thoughts (Lovett & Sheffield, 2007), while affective empathy, known as emotional contagion and experience sharing, is the capacity of an individual to vicariously feel others' emotional states (Blair, 2005). That is, cognitive empathy is predominantly an intellectual, perspective-taking process. In contrast, affective empathy involves having a corresponding emotional reaction to the emotions of other people.

Studies in psychology literature have examined and found the effectiveness of cognitive-empathy education, including experiential training, didactic, skills training, mindfulness training, and mixed methods. In particular, education materials that are designed to enhance perspective-taking skill, which is a key to cognitive empathy, have been found to be beneficial for improving empathy. For example, Hatcher et al. (2005) and Galinsky et al. (2005) showed that through perspective-taking exercises that involve imagining another's point of view, individuals can step outside of their own experiences to be open to those of the other person ("decentering") and suspend judgment. This process would lead to reductions in the activation of stereotypes toward other people and improvement in cognitive empathy. Although there are many factors that facilitate perspective-taking, one prerequisite is the ability to recognize and accept that people can have different perspectives toward the same situation. This is referred to as self-other differentiation and it has been shown to have several positive effects on empathy (Coplan, 2004). First, it prevents empathy-induced experiences from motivating the empathizer to act as though he or she is having the target's experiences. Second, it allows the empathizer to have his or her own separate experiences while simultaneously empathizing. Third, it enables the empathizer to observe the boundaries of the other as well as their own, and to respect the singularity of the other's experience as well as their own (Strayer, 1987).

Previous research has proposed different methods of empathy education using games, VR, and other technology. Evidence exists that video games are found to be effective for fostering empathy, cooperation and other positive social behavior in many populations, even if the players are concerned about winning the game (Konrath et al., 2011). For example, a Korean study showed the effectiveness of video games in enhancing empathy and prosocial behaviors among elementary school students and adolescents (Kim, 2005). In a Finnish example, a program that incorporated an anti-bullying computer game effectively reduced bullying rates in school, likely by increasing children's empathy (Poskiparta et al., 2012; Salmivalli et al., 2011). Further, according to Chen et al. (2018), the majority of participating university students agreed that learning empathy through video games was preferable and more effective than traditional didactics. Moreover, VR games can be more effective than 2D video games in terms of improving empathy (Herrera et al., 2018) because the sense of presence in VR and the sense of becoming a virtual character (embodiment) allow users to immerse themselves and have a vicarious experience (Wiederhold, 2020). Peck et al. (2013) found that when white people were placed in the position of dark-skinned avatars in VR, implicit negative bias toward black people was reduced, thereby showing the plasticity of empathy. In another study among Australian college students, participants in a VR condition experienced higher empathy with higher engagement than participants in a control group when they watched documentaries featuring young girls in refugee camps in VR and in two-dimensional format, respectively (Schutte & Stilinović, 2017). These examples demonstrate that VR has been successfully used for increasing empathy among participants, but none of them train users to understand the existence of different perspectives as a prerequisite of developing one's cognitive-empathy skills.

2.2 User experience of VR applications

Although the immersiveness of VR technology has increased and VR technology has become more accessible in recent years, there still remain significant research challenges to be solved, such as cybersickness, presence, embodiment, uncanny valley, and ethics (Pan & Hamilton, 2018). Of these, cybersickness, in particular, is a serious threat to the VR user experience (UX) because it can render the experience a nightmare through diverse symptoms such as discomfort, headache, fatigue, eyestrain, sweating, nausea, dizziness, vertigo, anxiety, and blurred vision (Bruck & Watters, 2011). Moreover, cybersickness can negatively affect presence (Weech et al., 2019), which is a key factor of successful VR UX.

Cybersickness, similar to motion sickness, is caused by the mismatch between visual motion that we observe through eyes in a VR environment and the lack of sensation of corresponding physical movement. Thus, cybersickness often happens in VR experiences where the user moves continuously using a joystick. By contrast, room-scale VR experiences that synchronize the user's physical movement to their avatar's movement in the VR environment are less likely to cause cybersickness. Similarly, teleportation is less prone to cause cybersickness than continuous movement. Cybersickness can be tackled by eliminating the contributing factors, such as tracking errors, motion-to-photon latency, screen flickering (LaViola, 2000), rapid user movement speed and rotation, fast acceleration, colors and contrast (Rebenitsch & Owen, 2021). Additionally, beginners may find it useful to first join shorter, gentler VR sessions prior to embarking on longer VR adventures so as to build up their "VR stamina."

One of the important factors that determine the immersive power of a game is the camera perspective used in the game, and this also applies to VR. In games and VR applications where the user controls a game character, the perspective can be divided into the first-person perspective (FPP), in which the camera is aligned with the eyes of the character, and the third-person perspective (TPP), in which the camera is located outside the character. Kallinen et al. (2007) discovered that FPP made computer game players feel a higher presence than TPP, but the difference in perspectives did not affect attention and emotions measured by pupil movements and facial electromyography. The Monteiro et al. experimental study (2018) on comparing TPP and FPP in VR games revealed that TPP is less immersive than FPP, but the latter is more likely to cause cybersickness. Moreover, users' preference between the two perspectives is not clear (Monteiro et al., 2018). In terms of effectiveness in empathy building, Kambe and Nakajima (2022) found that there was no significant difference between FPP and TPP in promoting other-oriented empathy for virtual characters in VR games. These findings do not clearly show whether TPP and FPP would be more suitable for VR-based empathy education, which led us to explore both in a formative evaluation of the proposed game.

3 Research design

The research design of this study is illustrated in Fig. 1. Three research questions (RQ1-RQ3) are answered with two methods: a Scrum-based game development method and a mixed-method formative evaluation. The details of the research questions and methods are explained in the following sections.

3.1 Research questions

The objective of this research was to propose a novel VR game for learning cognitive empathy. In addition, we sought to evaluate the game's usability and design concepts regarding content exhibition and camera perspectives (FPP, TPP). Accordingly, we formulated the following research questions:

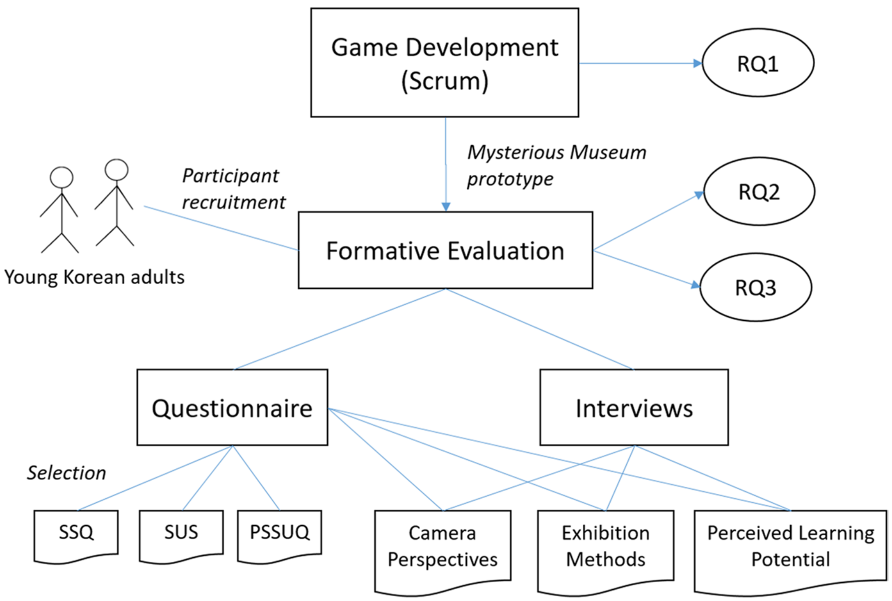

Fig. 1 Research design (SSQ: Simulator Sickness Questionnaire; SUS: System Usability Scale; PSSUQ: Post-Study System Usability Questionnaire; RQ: research question)

1. How can we design an immersive VR game for cognitive-empathy education to help users recognize and accept that people can have different thoughts and feelings about the same situation?
2. What content exhibition methods are suitable for the proposed immersive VR game for cognitive-empathy education?
3. What camera perspectives are suitable for the proposed immersive VR game for cognitive-empathy education?

3.2 Research methods

3.2.1 Game development method

The Mysterious Museum game was developed through Unity (2021.3.8f1) and XR Interaction Toolkit (2.0.2). The game was then executed on a Meta Quest 2 device, which is a standalone VR device with inside-out tracking comprising a head-mounted display (HMD) and hand controllers. Unity is a game engine that provides a development environment for 3D and 2D video games, and an integrated production tool for creating interactive content such as 3D animation, architectural visualization, and VR. The development was based on iterative prototype creation and assessment using the Scrum method (Sutherland, 2014). We developed game prototypes and held weekly review and planning meetings among developers and a project manager (scrum master). Designers and psychology experts joined some of the meetings to provide their ideas and opinions. At the meetings, the development process was shared, and feedback was obtained for continuous improvement.

3.2.2 Formative evaluation method

We used formative evaluation that enables designers of educational technology to obtain important information for the next steps of development (Flagg, 1990). In particular, we focused on investigating the game's usability and user experience along with comparison of design concepts related to content exhibition methods and camera perspectives. However, rather than testing the entire game, we conducted the formative evaluation on one of the two scenes of the game because the design concepts are similarly applied to both scenes.

We recruited 19 participants (11 females, eight males, age range: 22–32, and mean age: 25.4) among university students in the Republic of Korea using the non-probabilistic convenience sampling method (Henry, 1990) by posting recruitment flyers on university websites. The number of participants was deemed to be sufficient for a formative evaluation to identify major issues and receive feedback on the design concepts; in the classic usability testing guideline, five participants are recommended as adequate, and 15 is found to be the optimal number of participants for a user test in a medium-to-large project (Nielsen & Landauer, 1993).

The participants were young adults who gave their voluntary, informed consent prior to data collection.

In the questionnaire and interview, questions were asked about the participants' previous VR experience, cybersickness, usability of the game, and the proposed design concepts. The cybersickness statements were adopted from the Simulator Sickness Questionnaire (SSQ) (Kennedy et al., 1993), and the usability part was prepared by referring to the System Usability Scale (SUS) (Brooke, 1986) and the Post-Study System Usability Questionnaire (PSSUQ) (Lewis, 2019). In evaluating usability, we selected relevant statements from SUS and PSSUQ for measuring ease-of-use, learnability, information quality, and interface quality. These statements were presented with a four-point Likert scale where values 1 and 4 corresponded strongly to disagree and strongly agree, respectively. The interview questions aimed to collect the participants' in-depth perceptions and opinions about the game, with a specific focus on the game content and design concepts. The questionnaire and interview questions are presented in Appendices 1 and 2, respectively.

The data collection for the formative evaluation was conducted individually with 19 participants during one week in August 2022 and another week in February 2023. Upon arrival, the participant was briefly informed verbally about the research and VR game, and that the experiment could be stopped at any time if they felt sick or uncomfortable. Subsequently, the participant signed a consent form for information provision (recording the experiment and providing data for the study) and proceeded with the experiment. Six scenes with different design concepts were tested with two different content exhibition methods (3D gallery scene, conveyor belt scene) and three camera perspectives (FPP Fixed, TPP-FPP camera movement, TPP-FPP fade-in/out). The order of the scenes was randomly assigned to each participant. The researcher recorded the play screen for each scene while the participant was testing, and observed and recorded the user's reactions. At the end of testing a scene, a questionnaire about cybersickness was administered. At the end of the experiment, a questionnaire was conducted on items other than cybersickness, followed by an interview. At this time, the interview was recorded after obtaining the consent of the participant.

We analyzed the quantitative questionnaire data using visualization and descriptive statistics (sum, mean, standard deviation). We then analyzed the transcribed interview data and qualitative data from the questionnaire by coding (Saldana, 2016) in a spreadsheet application. In the first iteration of coding, we identified meaningful phrases from the participants' answers and assigned codes based on the research questions. In the next iterations, we reviewed, combined, and revised the codes, with emphasis on codes that helped to explain or support the findings of the quantitative analysis.

4 Results

4.1 Implementation of mysterious museum

The protagonist of Mysterious Museum is a robot who has the consciousness of the old engineer who created the robot. The robot, who lacks empathy, embarks on

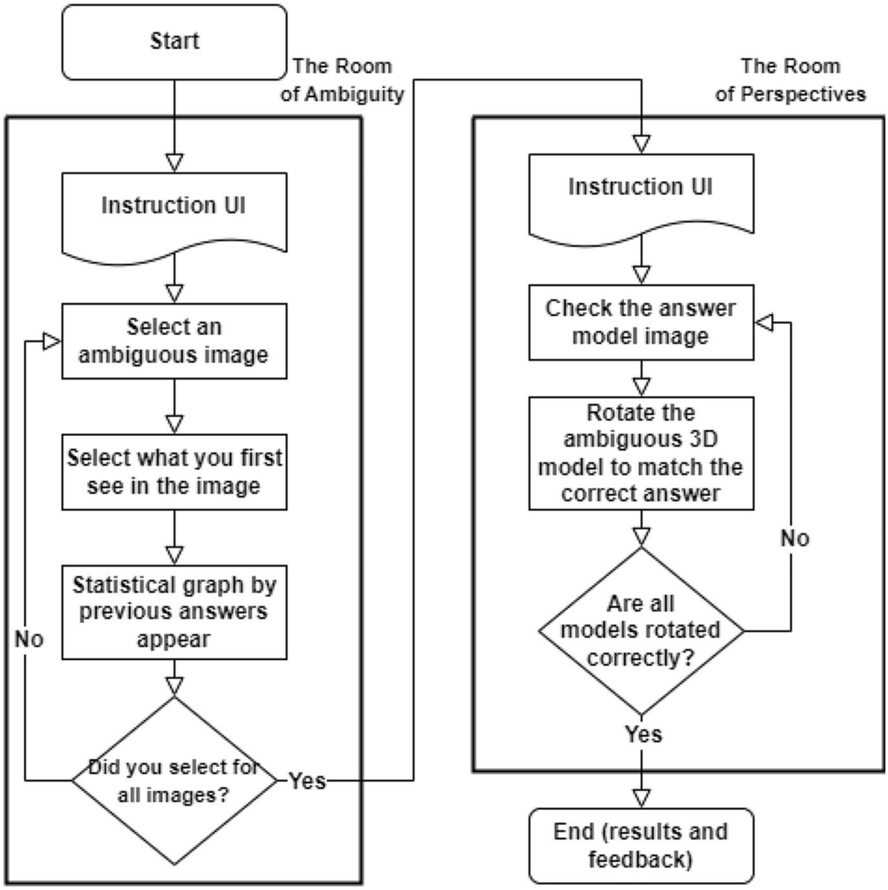

Fig. 2 Flowchart for Mysterious Museum gameplay

an educational adventure to develop its empathic ability, thus hoping to become a human. In the game, the player controls the robot using a joystick of the controller and interacts with objects and the user interface with a ray. The overall flow of the game comprises two scenes—The Room of Ambiguity and The Room of Perspectives—shown in Fig. 2. The details of the two scenes are explained in the following sections. We then explain the six game versions comprising different camera perspectives and exhibition methods that were evaluated in the formative evaluation.

The gameplay design is motivated by Visual Thinking Strategies (VTS), which is a pedagogical approach involving discussion of works of art aimed at encouraging learners to look carefully, verbalize their observations and ideas, and interact with others regarding their interpretations of the image (Reilly et al., 2005). VTS increases not only visual literacy but also the ability to self-reflect and a sense of empathy (Castillo et al., 2013). VTS is effective for empathy training because it exposes the participants to different interpretations of the same art image and learn

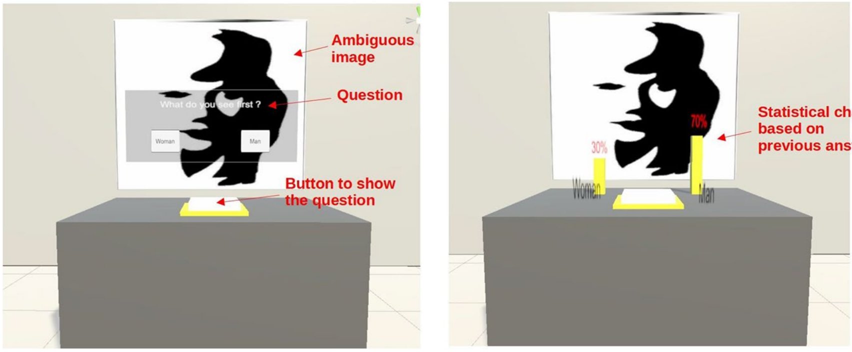

Fig. 3 Interaction with an ambiguous 2D image in the Room of Ambiguity. The labels and arrows are not in the gameplay

how to accept multiple interpretations and tolerate ambiguity (Bentwich & Gilbey, 2017). In the proposed game, VTS is applied in both scenes so the players can form different interpretations of the same content.

4.1.1 The room of ambiguity

Mysterious Museum begins with a scene wherein four ambiguous 2D images are initially covered by curtains. These ambiguous images look different depending on the user, and only images with permissive licenses (e.g., Creative Commons) were chosen for this scene. After watching brief instructions, the player selects one of the covered images that causes the curtain to open. The player observes the image and then presses a button placed on the table. A popup canvas appears with buttons representing multiple options whereby the player chooses the one that they first saw in the image. Figure 3a presents an ambiguous image with buttons for answer options. After the player gives an answer, a statistical bar chart (Fig. 3b) appears on the table illustrating players' answers thus far. Therefore, the player can see at a glance what other people saw first when looking at the image. The player repeats this process for the remaining images after which a portal opens that leads to the Room of Perspectives.

4.1.2 The room of perspectives

This scene presents the player with ambiguous 3D objects that appear different depending on the point of view. The 3D objects used in this scene were licensed under Creative Commons and were acquired from the UltiMaker's Thingiverse repository (UltiMaker, n.d.) that provides digital models of objects created by users. The objects are placed on a table in front of a virtual mirror, so the player can observe that objects appear different depending on the point of view by comparing the image in the mirror with the model on the table. The scene also has two buttons activated by the trigger button of the controller, to adjust the object's rotation

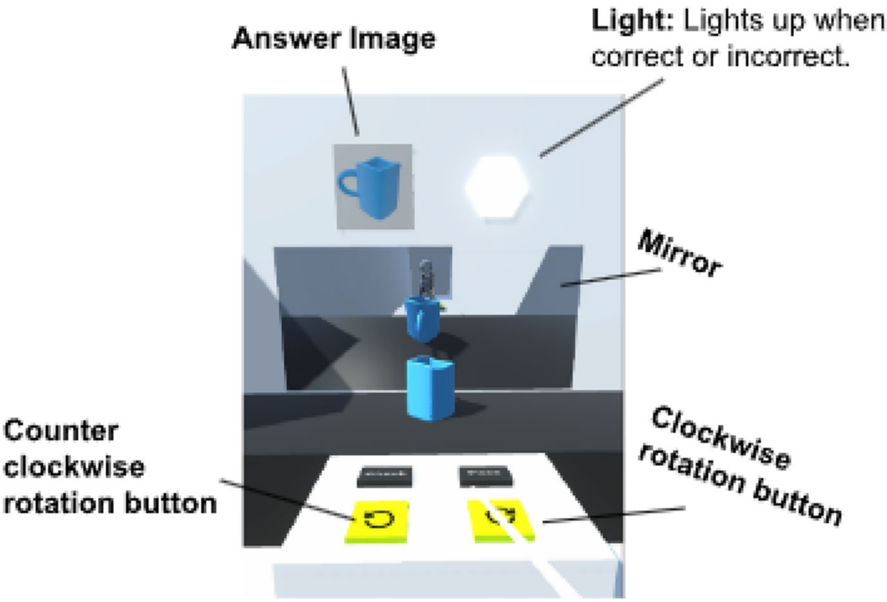

Fig. 4 The player (robot) observes an ambiguous 3D object from different perspectives in the Room of Perspectives

clockwise and counterclockwise. When a rotation button is pressed once, the object rotates 45 degrees. The puzzle can be solved by rotating the object until it matches the reference image shown above the model (Fig. 4). Once the player rotates all requested objects correctly, the scene ends.

For the purpose of the formative evaluation, two content exhibition methods were implemented for this scene: "gallery" and "conveyor belt." Three camera perspective methods were used for each of these two methods: "FPP Fixed," "TPP-FPP camera movement," and "TPP-FPP fade-in/out." The last two use the same camera perspectives but the transitions between the perspectives are different. The "TPP fixed" perspective was omitted because it would prevent the player from having a close-up view of the museum objects, which is essential for the gameplay. By combining these, there were a total of six versions of the Room of Perspectives. The goal of evaluating these versions in the formative evaluation was to provide us with information to help choose the version that most attracts the user's interest and has the least negative effects such as cybersickness. The details of the camera perspective and exhibition methods are explained in the following sections.

4.2 Camera perspective

Our iterative development process resulted in three design concepts for the camera perspective method, which were then evaluated in the formative evaluation. These design concepts are explained in the following sections.

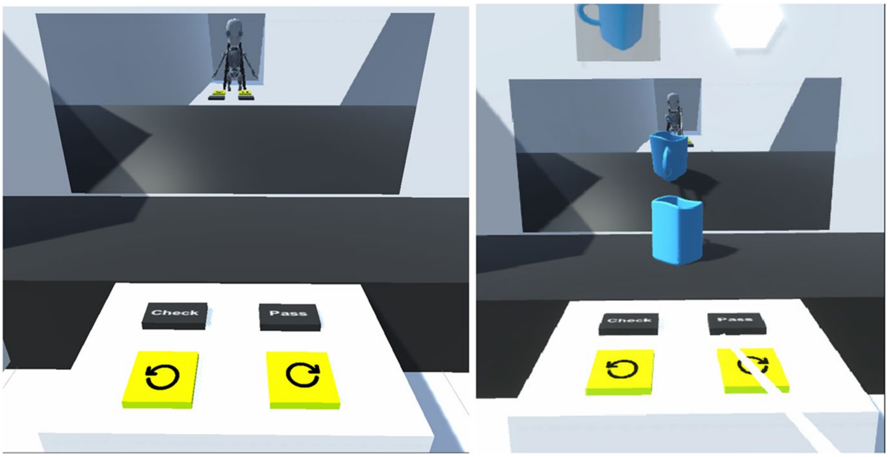

Fig. 5 In the FPP Fixed perspective, the player watches the game environment through the eyes of the robot

4.2.1 FPP fixed

In this perspective design concept, the player takes the perspective of the robot, and the player's appearance and movements are synchronized with the robot (embodiment). The player can see the robot through the mirror in the 3D scene (Fig. 5). This design intends to strengthen the feeling of embodiment in the player, which in turn can enhance the sensation of presence (Biocca, 2006). However, the player's ability to observe the physical environment is somewhat limited as they are bound to the robot's perspective.

4.2.2 TPP-FPP camera movement

There are two perspectives in this design concept: TPP and FPP. The scene starts with a bird's eye TPP that displays the overall game elements, such as robot movement and room structure (Fig. 6a). The player can rotate the camera by moving their head, but the camera movement is otherwise restricted. When the user

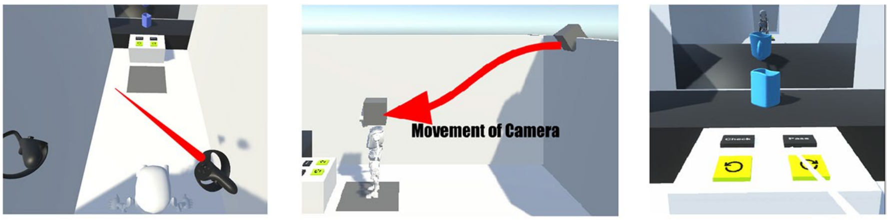

Fig. 6 Change of the perspective from TPP (**a**) to FPP (**c**) by camera movement (**b**)

enters a specific area in front of a 3D object, the perspective changes from TPP to FPP by moving the camera with linear interpolation (Fig. 6b). In FPP, the game is played from the robot's point of view as shown in Fig. 6c. When the player moves the robot away from the object, the TPP is resumed with a reverse movement by linear interpolation. The user can feel this viewpoint change as if riding a roller coaster. The goal of this camera movement technique is to always keep the player aware of where they are heading.

4.2.3 TPP-FPP fade-in, fade-out

This design concept comprises two perspectives: TPP and FPP. The scene starts in the TPP, and when the robot enters a specific area in front of a 3D object, the perspective changes from TPP to FPP. The perspective is changed back to TPP when the player leaves the area. Here we used fade-in/out effects to simulate closing and opening eyes when the perspective changes. The goal of this camera transition technique is to avoid any discomfort caused by unexpected camera movements.

4.3 Exhibition method

Both scenes in the Mysterious Museum include a number of objects presented to the player. We created two design concepts for exhibiting these objects—a gallery and conveyor belt—and implemented them in the Room of Perspectives.

4.3.1 Gallery

This exhibition method is inspired by museums and art galleries, where several objects are presented in a room and the player is free to visit the exhibits in any order (Fig. 7a). The player is presented with four ambiguous 3D objects placed in front of four mirrors (Fig. 7d-g). The purpose of the mirrors is to show the player a perspective opposite to the object. The player rotates the object until it matches the image shown above the mirror (Fig. 7b), after which a checkmark appears (Fig. 7c). The player must move the robot from one table to another to solve all puzzles. The game was completed when all four models matched the correct answer.

4.3.2 Conveyor belt

This design concept was created to allow the player to focus fully on objects without having to move from one table to another. There is only one table in front of a mirror and a conveyor belt that moves the exhibits in front of the player (Fig. 8a). The player rotates an ambiguous 3D model placed on the conveyor belt to match the correct answer in the same way as in the gallery method (Fig. 8b). To check the answer, the player presses the "Check" button and a check mark appears for

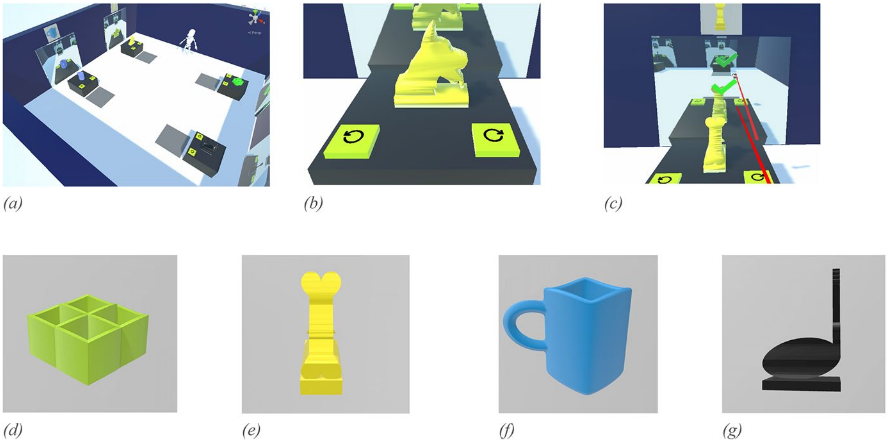

Fig. 7 The gallery exhibition method: (**a**) gallery from the TPP perspective; (**b**) an ambiguous 3D object (a dog or bone) with rotation buttons; (**c**) the object has been rotated correctly; (**d**-**g**) ambiguous 3D objects used in Mysterious Museum

a few seconds if the answer is correct. Then the conveyor belt will move to bring a new object in front of the user. In this design concept, we also included objects that do not have a correct answer to make the gameplay more challenging. When such an object appears, the user must move the conveyor belt by pressing the "Pass" button (Fig. 8c). When the player rotates the objects according to the reference images, the game is complete.

4.4 Formative evaluation

4.4.1 Demographics and previous VR experience

The formative evaluation participants consisted of 11 females (58%) and eight males (42%), with an average age of 25.4 years (range 22–32). The participants were graduate and undergraduate students majoring in digital media or

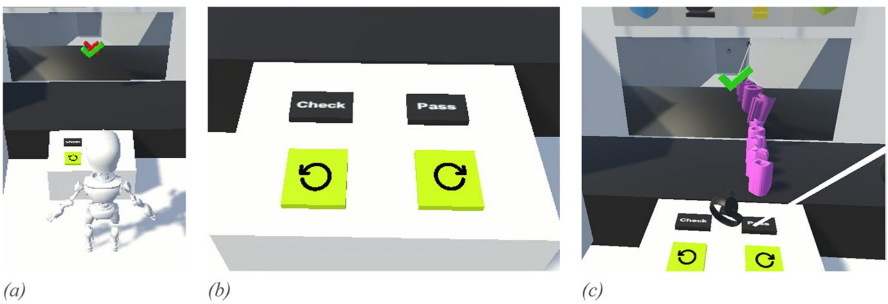

Fig. 8 The conveyor belt exhibition method: (**a**) TPP of the robot standing in front of the conveyor belt; (**b**) buttons on the table to rotate, check or pass an object; (**c**) an object brought to the player by the conveyor belt

psychology. Among the participants, one had never experienced VR before, eight rarely used VR, four had experienced VR occasionally, and six had experienced VR frequently. Therefore, we can conclude that approximately half of the participants used VR little or not at all before, and approximately half were somewhat familiar with it.

4.4.2 Usability

Figure 9 shows the results of the usability evaluation based on seven selected statements from the SUS and PSSUQ questionnaires. The mean of all usability statements is 2.92, which corresponds to 72.9% of the maximum score. This result indicates that the game has moderate usability. The learning curve of Mysterious Museum was somewhat steep for some participants, as the results of statements 3 ($\mu = 2.95$, $\sigma = 0.91$) and 4 ($\mu = 3.05$, $\sigma = 0.78$) indicate. There were four and three participants who found the system to be complex ($\mu = 3.05$, $\sigma = 0.71$) and who disagreed with the system being easy to use ($\mu = 2.74$, $\sigma = 0.81$), respectively.

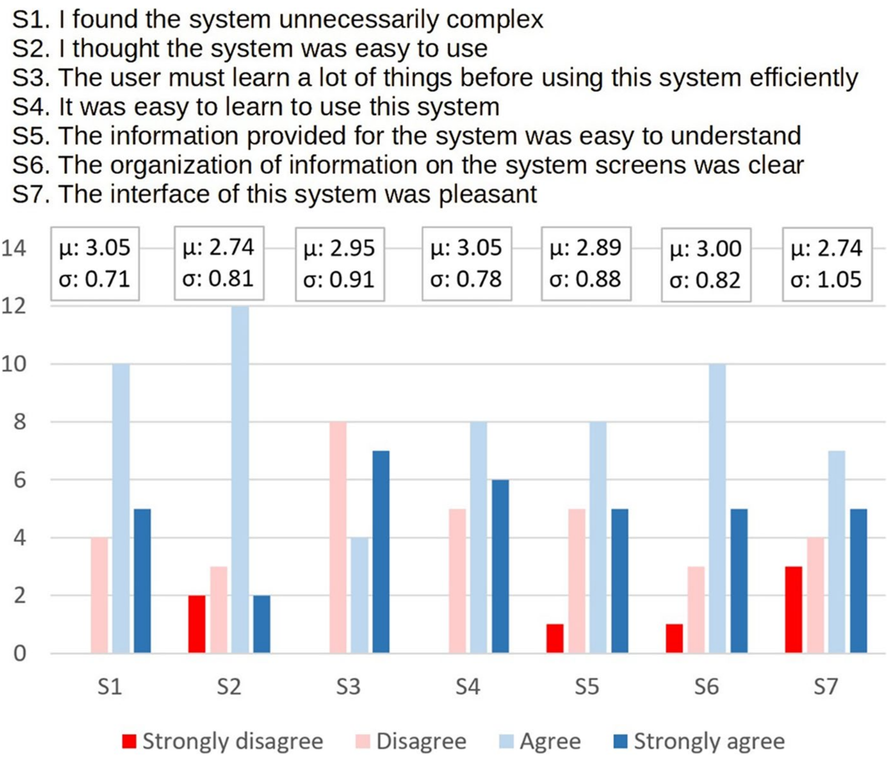

Fig. 9 Results of the usability statements. The data of S1 and S3 were inverted as they are negative statements. Values 1–4 represent a Likert scale where 1 is strongly disagree and 4 is strongly agree

These results are aligned with the answers to the statement about clarity of information provided, with which six participants disagreed ($\mu = 2.89$, $\sigma = 0.88$). This suggests that the game lacked sufficiently clear instructions for the use of VR devices and gameplay. Related to this, one participant reported difficulty sing the VR controller:

> "The operation of the controller was difficult." (Female, 22)

The use of VR hardware was also found to cause some usability issues due to various reasons such as the device's weight, form factor, and discomfort when wearing glasses. The following interview excerpts demonstrate that these issues are solvable in future device designs:

> "The HMD is heavier than expected." (Female, 26)
> "The HMD pressed my head and made it uncomfortable." (Male, 27)
> "My glasses do not fit into the VR device." (Male, 28)

The purpose of Mysterious Museum is to train players in cognitive empathy with a focus on realizing the existence of different perspectives. In the Room of Perspectives, the player's goal is to find out that when the object is seen through the mirror it looks different than when the object is observed directly, so the mirror is a key gameplay element. However, as the following interview excerpts show, some of the participants wondered about the function of the mirror and what cognitive-empathy education was about:

> "I don't understand the need for a mirror." (Female, 22)
> "I don't feel much of a connection to cognitive empathy." (Female, 24)

In the evaluated version of Mysterious Museum, the game's tutorial did not adequately explain the purpose of the mirror and how the game relates to cognitive empathy. Nor did the tutorial provide sufficient information about how to use the controller. It is therefore necessary to explain the pedagogical goal and approach, as well as how to use the controller, in the tutorial of the game. These aspects of the insufficient tutorial are illustrated in the following quotes from the interviewees:

> "I wish there was a more detailed description of the operation at the beginning of the game. [The] tutorial needs improvement." (Female, 28)
> "In the introduction tutorial, I hope there is a way to intuitively know whether the image in the mirror is the correct answer, or the correct answer when the user sees it." (Female, 32)

However, a detailed tutorial may not be necessary for all users, especially those with significant experience with VR; one participant was able to discover the function of the mirror while playing Mysterious Museum:

> "Even if it's the same object, it can look different depending on different angles, and it can be observed differently through the mirror." (Male, 22)

This comment also reveals that the Mysterious Museum's learning objective worked for this participant; the game enabled the participant to recognize and accept that there are different perspectives of the same object depending on the observation angle. Of course, this realization should still be explicitly connected to the concept of cognitive empathy for the player to understand that this is part of the process of developing one's cognitive empathy. We explore perceived learning potential more in Sect. 4.4.6.

When we asked the participants what they liked about the Mysterious Museum game, they cited the mirror, novelty, optical illusions, conveyor belt, background music, the control ray, and finding the correct answers as the sources of interest and fun. Therefore, these gameplay elements act as as motivational factors that help maintain player engagement despite usability issues. However, as the usability issues will be resolved based on the findings of this formative evaluation, we expect the motivational power of the gameplay elements to be strengthened.

4.4.3 Cybersickness

Figure 10 shows the cumulative scores of the reported cybersickness symptoms for each scene version. The scores 0–3 were distributed so that 0 was used when the participant selected "I didn't feel it at all," and 3 was used when the participant answered, "I felt it badly." After scoring 0–3 for each response, the scores were added for each scene. These results indicate that the scene that caused the most cybersickness was gallery with TTP-FPP Camera Movement. As for the exhibition method, the conveyor belt (109 in total) elicited fewer symptoms of cybersickness than the gallery (256 in total). As for the perspective, FFP Fixed showed the fewest symptoms of cybersickness (83 in total). Of the symptoms,

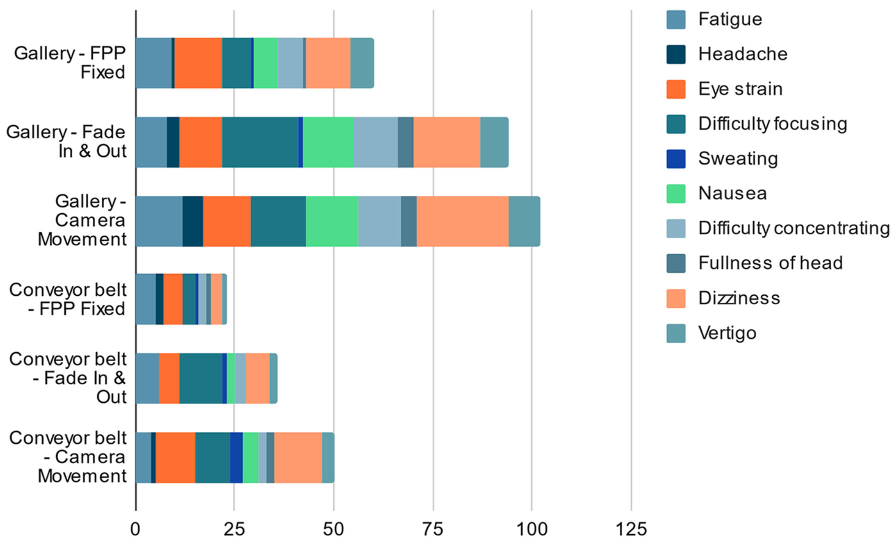

Fig. 10 Results of the cybersickness statements

dizziness, nausea, difficulty of focusing, difficulty of concentrating, and eye strain occurred most often.

Unlike the Conveyor belt method, the Gallery exhibition method changes the camera perspective at least four times when the player visits each table. Therefore, the tendency to feel cybersickness grows significantly when the camera perspective changes, regardless of whether the camera is moved or faded out/in. Related to this, one participant said the following when asked about how they felt when they felt cybersickness:

> "I felt a bit like riding a roller coaster with the camera movement." (Female, 22)

4.4.4 Exhibition method preference

We investigated which of the two exhibition methods designs—the gallery or conveyor belt—was preferred among the participants. Figure 11 shows the results, indicating that only four participants preferred the gallery, and 15 participants preferred the conveyor belt. The following comments from some of the participants indicate that the reasons for preferring the conveyor belt included having multiple buttons to press, increased curiosity over incoming objects, and the rattling and movement of the conveyor belt:

> "There are details about the shaking of the objects when the conveyor belt moves, and the elements in the game are fun." (Female, 22)
> "It is fun in the conveyor belt scene because I don't move and other things move." (Female, 22)
> "The conveyor belt scene and the rattling animation when an object stops were fun." (Female, 32)
> "Conveyor belt because there were many options and buttons." (Male, 29)

This result is aligned with the cybersickness results in Fig. 10 that show the gallery causing many more cybersickness symptoms among the participants. This correlation suggests that a negative factor such as cybersickness may significantly influence users' preferences on gameplay. Nevertheless, there were a few participants

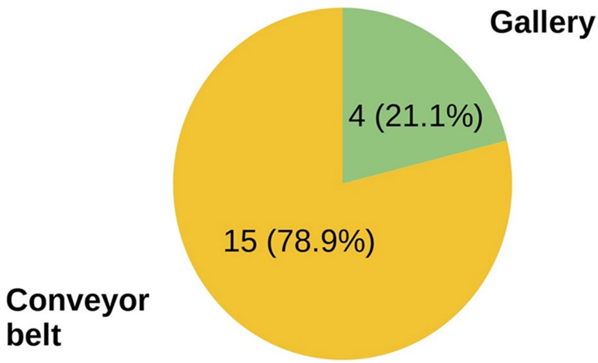

Fig. 11 Exhibition method preference

who preferred the gallery scene for different reasons. The following participant enjoyed the dynamicity of the VR environment exploration:

> "I could fully feel the VR elements because there were many changes of perspective." (Female, 30)

4.4.5 Camera perspective preference

Figure 12 shows the participants' preferences for the camera perspective designs. TPP-FPP camera movement was the least preferred (two participants, 10.5%), which is aligned with the fact that TPP-FPP camera movement caused the greatest number of cybersickness symptoms of all perspectives, as shown in Fig. 10. The cybersickness results are also echoed in the FPP Fixed being the most preferred perspective (12 participants, 63.2%), as it does not include sudden perspective changes unlike the other two perspectives. Nevertheless, some participants found that TPP has some merit in being able to see the scene better:

> "In TPP it was nice to see the scene as a whole." (Female, 26)
> "The physical distance was much more felt when in the third-person perspective." (Female, 30)

Interestingly, the participant who answered that she felt like riding a roller coaster when we interviewed her about the symptoms of cybersickness answered that the camera movement is a fun factor in the experience:

> "The camera movement is lively and fun like riding a roller coaster." (Female, 22)

This indicates that even though movement in a VR experience may cause symptoms of cybersickness, it can still be fun and enjoyable to some users. Moreover, based on the following comments from other participants, there are mixed opinions

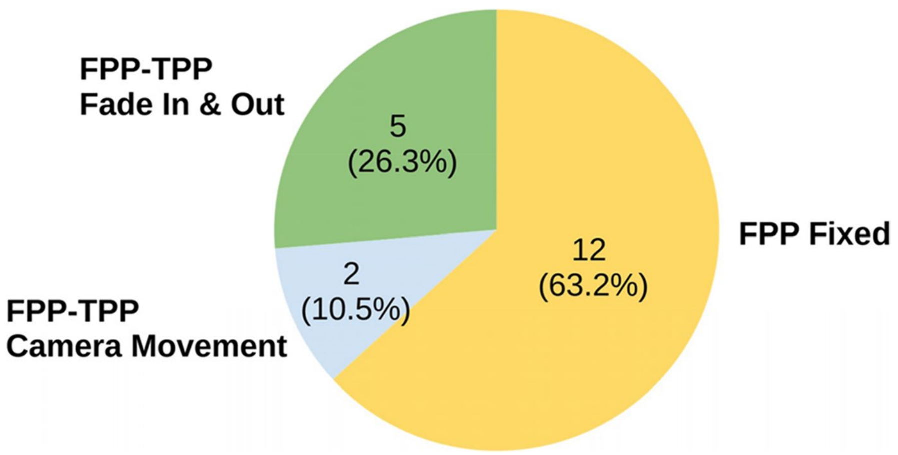

Fig. 12 Camera perspective preference

on whether or not the change between TPP and FPP perspectives facilitates immersion, thus suggesting a need for camera perspective personalization:

> "I felt a sense of immersion through a change of perspective as it added dramatic elements in the game." (Female, 23)
> "This game requires concentration, but when changing the perspective, the immersion of the game decreases, so fixing the perspective is more appropriate for this content." (Male, 26)
> "The function of the change of perspective is questionable. When there is a change in perspective, the sense of immersion is cut off." (Female, 25)

Related to this, the same female (25) participant suggested in the quote below that the FPP Fixed camera perspective would be more suitable for increasing immersion. Another female (28) participant felt less cybersickness with FPP and also noted the advantage of simple gameplay. Moreover, our analytic results indicate that previous experience with VR may play some role in preferences for the camera perspective. This was echoed in the last quote below which was uttered by a participant who was experienced in VR:

> "The fixed viewpoint did not break the sense of immersion, and a sense of unity was felt." (Female, 25)
> "The fixed FPP is appropriate because I felt less motion sickness and it provides simpler gameplay." (Female, 28)
> "Fixed perspective is good for beginners." (Male, 23)

4.4.6 Perceived learning potential

Although we did not investigate the learning effect of the game because it is still incomplete, we asked the participants what they think about learning cognitive empathy with VR using a game, given their experience with Mysterious Museum. This was done to understand whether young adults would perceive a VR game as a potential method for learning empathy. Most of the participants gave positive responses to this method, with several of them suggesting that learning cognitive empathy through VR can be effective, as the following quotes suggest:

> "I think it is effective to learn cognitive empathy, which is difficult to learn, through virtual reality." (Female, 23)
> "I think it will be more effective than learning through other methods." (Male, 23)
> "Think there are more effective parts compared to using other existing media (direct experience, writing, video, etc.)" (Female, 32)
> "I think it's okay to use VR to learn cognitive empathy. I think it's a more interesting way to immerse students in a game than teaching them with real objects, and I think it can really help them improve their cognitive skills." (Male, 22)

However, there were also contradicting opinions on the effectiveness. The following participants pointed out that the unfamiliarity of the concept and lack of educational content might be barriers to learning cognitive empathy, while the first participant also suggested that VR immersion affords the potential for learning:

> "As the concept of cognitive empathy itself was unfamiliar, it was not easy to know what to learn. If an element of immersion is needed, learning through VR seems to be effective." (Female, 22)
> "It is insufficient content to learn empathy. It is possible to simply learn seeing differently depending on the perspective, but it is difficult to see an improvement in empathy." (Female, 28)

This is an indication that a proper tutorial is needed not only for teaching the gameplay mechanics but also learning objectives and concepts related to them. Nevertheless, several participants mentioned that the game, especially the mirror and the 3D objects, helped them understand that different perspectives can exist, thus indicating that the game has potential to fulfill its educational purpose. The following comments from the interviewees exemplify this:

> "Through the mirror, it was possible to recognize that an object is seen differently depending on the angle." (Female, 28)
> "It was nice to be aware that objects can look different depending on the angle." (Female, 28)
> "It was nice to recognize that objects look different when viewed from different angles." (Male, 25)

Fun and novelty were identified in the answers of two participants, which are thus potential motivators for using a VR game as an empathy-learning tool:

> "It's not the kind of cognitive-empathy training I've come across before, so I think it's a new and fun idea. The fact that you're playing the game in a VR environment adds to the immersion and excitement." (Female, 25)
> "It seems to be fun to do, but it seems to be difficult to operate for children." (Male, 22)

The second statement revealed a potential issue of using VR technology for education: operating the HMD and controllers is not easy if the learner is using VR for the first time and the form of HMD may cause discomfort, especially among children. Thorough and self-paced onboarding for new users, as well as ensuring a good fit of VR hardware, are therefore essential for ensuring a smooth start to a VR learning process.

We also asked the interviewees whether they had learned anything during the gameplay. Three of the participants reported that they did not learn anything. A majority of the other participants cited learning that objects look different depending on the perspective, but some participants reported other, unexpected learning outcomes, as the following excerpts demonstrate:

> "I learned to observe objects of different shapes from different sides." (Female, 22)

"Learning to see the same thing differently depending on the angle." (Female, 30)
"The game improves spatial perception." (Male, 22)
"I learned to pay more attention to objects in the game." (Female, 22)

The last two quotes are particularly interesting as they could be applied to different types of immersive VR contents. Being immersed in a virtual world and observing it from different perspectives provides users with unique affordances that are difficult to replicate in the real world. This may be what one male (22) meant by improving spatial awareness. In fact, he had never used VR before, therefore the gameplay was likely an impressive experience for him. The last quote, which is from a female (22) with only a little VR experience, indicates that immersive VR makes it possible to focus on surrounding objects and details. However, this is likely to depend on the game design: Mysterious Museum was designed to keep the player focused on the learning task, so there are only a few other game aspects that could nudge the focus of the player to deviate from the learning task.

5 Discussion

The proposed Mysterious Museum VR game provides a novel approach to cognitive-empathy education through the themes of ambiguity and different perspectives. The game aims to make the player realize the existence of various perspectives even under the same circumstances and the need for understanding these perspectives in the process of developing cognitive empathy. Although empathy education games have been explored in previous studies, the aspects of realizing and accepting the existence of other perspectives for the sake of empathy education have not been explicitly presented in a learning game. Mysterious Museum accomplishes this through two levels where the player observes 2D images and 3D models, respectively, from various perspectives to solve related puzzles. This is a simple, to-the-point method that enables high player engagement with the learning activity. Although we did not measure the effectiveness of Mysterious Museum as a cognitive-empathy-learning tool in the formative evaluation, our observations and the participants' responses suggest that the game has potential as a learning tool as long as the learning objectives and method are explained well to the player. The results of this study will be of interest to various groups including researchers, designers, psychologists, and teachers working with VR-based education.

5.1 Usability

The version Mysterious Museum used in this study was a playable prototype with the key gameplay features implemented. The formative evaluation conducted was to provide useful information for guiding future development steps. Therefore, the main foci of the formative evaluation were on usability and cybersickness, as well as several design concepts regarding content exhibition methods and camera perspectives. Although the usability results were fairly good, there were significant issues regarding the quality and clarity of the information provided to the player, as well as the overall learning curve of Mysterious Museum. In particular, several participants pointed out the lack of explanation for the purpose of the mirror and the game's connection to cognitive empathy; these are essential for achieving the game's goal as a cognitive-empathy learning tool. The high learning curve can be partly attributed to half of the participants having little or no experience with VR. Nevertheless, Mysterious Museum should provide a better onboarding experience and clearer instructions on aspects such as game control and learning objectives.

5.2 Cybersickness

The results on cybersickness revealed that the gallery scenes caused more symptoms of cybersickness than the conveyor belt scenes. One likely explanation is the greater amount of movement required in the gallery scenes, which aligns with previous research suggesting movement is one of the causes for cybersickness (Rebenitsch & Owen, 2021). In general, the sensitivity to cybersickness and experienced symptoms vary from person to person, and it is one of the key challenges in VR development (Pan & Hamilton, 2018). Designers of VR experiences can mitigate this challenge by countering the factors known to cause cybersickness. For example, cybersickness can be caused by errors in user tracking, motion-to-photon latency, screen flickering (LaViola, 2000), rapid movement speed, rotation and acceleration, and strong colors and contrast (Rebenitsch & Owen, 2021). The formative evaluation participants were young adults, who are known to be more resistant to cybersickness than older people (Ramaseri Chandra et al., 2022). Therefore, we intend to limit the risk factors of cybersickness in future versions of this game. For example, the TPP-FPP camera movement design could be improved by reducing the acceleration speed and implementing tunnel vision, which limits the player's field of view with an artificial tunnel at the edges of the screen during movement. This technique has been used in commercial high-speed VR games, such as the Epic Roller Coasters. Finally, as long VR experiences increase the likelihood of cybersickness, it is recommended that VR sessions be kept fairly short and sufficient breaks be taken between sessions (Ramaseri Chandra et al., 2022).

5.3 Content exhibition methods and camera perspectives

One of the goals of this study was to identify design concepts to be developed further based on the formative evaluation. The choice between the two exhibition methods is clear: as 78.9% of the participants chose the conveyor belt, we intend to focus on it in future development. In addition to being fun, the conveyor belt method significantly helped reduce the symptoms of cybersickness. This result can be partly attributed to the decreased player movement compared to the gallery method, as especially rapid artificial movement can contribute to cybersickness (Rebenitsch & Owen, 2021).

The results on the preferred camera perspective design concept showed that a majority of the participants (63.2%) chose FPP Fixed. The TPP-FPP camera movement design concept, which was described as riding a roller coaster by some participants, was the least preferred as only 10.5% participants chose it. These results are aligned with the results of cybersickness, and TPP-FPP camera movement cannot be recommended for use in its current form. However, we believe that the amount of cybersickness can be significantly reduced with the aforementioned design and technical solutions. The difference in cybersickness symptoms between the TPP and FPP methods was more significant in the gallery exhibition method where the player moves more, and the camera movement distance is larger than in the conveyor belt exhibition method. This result of experienced cybersickness between TPP and FPP is aligned with the results of Monteiro et al. (2018). However, they also found that FPP is more immersive than TPP, which unlike our results showed that perspective change methods could increase immersion for some participants. However, as we did not measure immersion, this evidence is merely suggestive, and another study is needed to identify whether perspective change techniques—with appropriate remedies against cybersickness—can increase immersion in VR games.

When we chose to implement the TPP-FPP fade-in/out method, we hypothesized that it would be less prone to cybersickness than the TPP-FPP camera movement method because continuous movement is a significant contributor to cybersickness. However, the difference between the two was small, which suggests that both methods could trigger the mismatch between the visual and vestibular senses. This finding is significant as it indicates that fade-in/out, which is sometimes used to implement teleportation in VR, can be nearly as cybersickness-prone as continuous involuntary movement. However, as our study sample was fairly small, more research is needed to investigate the differences between the TPP-FPP camera movement and TPP-FPP fade-in/out methods in terms of cybersickness.

Based on our analysis of the participants' preferences on the camera perspective methods, we conclude that FPP Fixed method is a good candidate for immersive VR content that requires movement of the user. However, we plan to provide different perspectives from which the player can choose. Moreover, these results on the proposed design concepts can be used by VR experience designers as references when deciding the types of object exhibition, camera perspective, and avatar movement.

5.4 VR for empathy education

Immersive VR has been found to be suitable for empathy education because it enhances the senses of presence and embodiment (Wiederhold, 2020). These factors are closely related to perspective-taking as an effective empathy-training method that aims to accept and understand another person's perspective (Galinsky et al., 2005; Hatcher et al., 2005).

The proposed Mysterious Museum game aims to provide empathy training for achieving the necessary pre-requisites for perspective-taking exercises; although the game does not present social situations for the player to analyze, role-play, or take perspectives, the game's tasks were designed to nudge the player to realize that people can experience the same situation differently.

One can justly ask why Mysterious Museum was implemented in VR because it does not involve any social situations, and it can be played on a personal computer as well. The game was developed in the VHEX project, which aims to develop a VR-based empathy diagnosis tool and various gamified VR contents for empathy education. We are currently in the process of combining Mysterious Museum with other games, all of which have a specific approach to empathy education. Mysterious Museum is the first game to be played as it covers the prerequisite skills required for cognitive empathy, which form the basis for the following games. For example, after playing Mysterious Museum, the player can enter another game called Noisy School Trip where the player observes virtual children interacting with each other, while trying to guess how they feel in each situation. In the future, we plan to explore how these games affect the player's empathy skills, and what effect the presence or absence of Mysterious Museum as the first game played has on the learning effect of other games.

The gameplay design of Mysterious Museum was motivated by the VTS pedagogical approach that promotes different interpretations of the same content while increasing the learner's tolerance of ambiguity (Bentwich & Gilbey, 2017). Tolerance of ambiguity, embedded within art, is related to an enhanced empathic ability through imagination. Dewey contends that the arts enable us to "enter, through imagination and the emotions they evoke, into other forms of relationships and participation than our own" (English, 2016, p. 336). According to Bentwich and Gilbey (2017), "empathy necessitates the ability to see 'the world' from the other person's viewpoint, while keeping well-drawn boundaries between self and other," which depends on acknowledging the existence of other views of the world or multiple interpretations of it. This ability is also referred to as tolerance of ambiguity (English, 2016), thus empathy and tolerance of ambiguity are closely related.

5.5 Implications of the findings

Based on our review of previous research, most previous approaches to game-based empathy education focused on scenario-based content where the player either observes or participates in a social situation or storytelling that involves emotion-evoking content and possible role-play (Chen et al., 2018; Kim, 2005; Peck et al., 2013; Poskiparta et al., 2012). Mysterious Museum differs from these games because it has a different objective, namely, to facilitate acknowledgment and acceptance that other people may have different perspectives in the same situation, which is a prerequisite for developing cognitive empathy. This is done in the absence of social situations by allowing the player to fully focus on ambiguous 2D images and 3D objects. Therefore, our approach provides a pioneering example of cognitive-empathy education that covers the first steps of the learning process. Consequently, this opens new research avenues on the relationship between prerequisite skills and scenario-based cognitive-empathy education, and the role of social situations in cognitive-empathy education.

The formative evaluation results' impact on design concepts related to camera perspectives and content exhibition methods informed us on the preferences young adults have regarding the design concepts and how much cybersickness each concept combination caused. The findings were aligned with previous results on cybersickness (e.g., movement causes cybersickness); however, they also revealed that preferences concerning the design concepts were mixed. The findings indicate that although the sample was demographically uniform, there is diversity on previous VR experience, personal preferences, and proneness to cybersickness. Therefore, an important lesson learned from the formative evaluation results is that future immersive VR education tools should be designed to provide multiple approaches to content exhibition and camera perspectives. Formulating detailed recommendations and guidelines on these aspects requires a further study with more diverse content, VR equipment, and participants.

5.6 Limitations

This study has several limitations. First, although the sample size is sufficient to identify issues in a usability study (Nielsen & Landauer, 1993), it is too small to demonstrate statistically significant results. The interview results, however, provided valuable information to support and explain the quantitative results. Second, the participants of the study were young adults on their 20 s, so more data are needed from users of other age groups. Finally, the formative evaluation did not explore the educational effectiveness of Mysterious Museum, although the interview results hinted at some perceived learning outcomes. After finalizing the implementation of the game features, we plan to test Mysterious Museum with at least 50 more participants of different ages to gather more detailed data on whether the game is enjoyable and meets its educational goals.

6 Conclusion

As empathy is one of the essential abilities of human beings that make us human, it is important to ensure that people are able to develop it. Researchers have proposed many empathy education interventions to facilitate this process, However, there is a lack of studies that develop and evaluate VR games for cognitive empathy that specifically focus on recognizing and understanding different perspectives that people may have under similar circumstances. The purpose of this study was to present a novel VR game concept for helping learners recognize and accept different perspectives on the same content, and explore, from a user-experience perspective, the gameplay and different design concepts related to camera perspectives and content exhibition methods.

We resolved the first research question "how can we design an immersive VR game for cognitive-empathy education to help users recognize and accept that people can have different thoughts and feelings about the same situation?" by proposing an immersive VR game Mysterious Museum where the player controls a human-wannabe robot and solves puzzles involving ambiguous shapes and objects that prompt them to recognize different perspectives. The mixed-method formative evaluation with questionnaire and interview instruments was conducted with 19 young adult participants to measure usability, cybersickness, perceived learning potential, and the participants' preferences regarding the design concepts. The usability results revealed that the Mysterious Museum's usability is good, albeit with a few issues related to learnability and information delivery.

To answer the second research question, "what content exhibition methods are suitable for the proposed immersive VR game for cognitive-empathy education?," we proposed two methods for exhibiting ambiguous objects: the gallery and the conveyor belt. These methods were combined with three camera perspective methods that were developed to find an answer to the third research question: "what camera perspectives are suitable for the proposed immersive VR game for cognitive-empathy education?" We then evaluated a total of six versions of the scene with the participants. The cybersickness questionnaire results revealed that the gallery method versions caused more cybersickness than the conveyor belt methods; the latter was preferred by most of the participants. Regarding the camera perspective methods, FPP Fixed, which maintains the first-person view throughout the gameplay, was the most preferred method, and also caused the fewest cybersickness symptoms. However, there also were participants who preferred other camera perspectives, so our conclusion is that Mysterious Museum should allow the player to choose between different camera perspective methods.

In future research, we plan to develop the proposed game by fixing the discovered issues, implementing more countermeasures against cybersickness, and combining Mysterious Museum with other empathy education contents currently being developed in the VHEX project. We also seek to conduct a study that examines whether Mysterious Museum improves the player's ability to respect other people's perspectives, thereby enhancing their cognitive-empathy ability. Finally, we are interested in measuring the learning outcomes of players using Mysterious Museum and other related games developed in the VHEX project. Moreover, we intend to investigate whether any relationship exists between the design concepts presented and learning outcomes.

Appendix 1: Questionnaire

Demographics and previous experience

- Gender: male / female / other
- Age:
- How often have you been using VR before this test?
  - I didn't use it at all.
  - I rarely use it.
  - I occasionally use it.
  - I use it frequently.

Cybersickness

Please select how much you experienced the following symptoms.*

	I didn't feel it at all	I barely felt it	I somewhat felt it	I felt it badly
Fatigue				
Headache				
Eyestrain				
Difficulty focusing				
Sweating				
Nausea				
Difficulty concentrating				
Fullness of head				
Dizziness				
Vertigo				

* This table was presented to the participants after each of the six design concept combinations

Usability

Please select to what extent you agree with each of the following statements.

	Strongly disagree	Disagree	Agree	Strongly agree
I found the system unnecessarily complex				
I thought the system was easy to use				
The user must learn a lot of things before using this system efficiently				
It was easy to learn to use this system				
The information provided by the system was easy to understand				
The organization of information on the system screens was clear				
The interface of this system was pleasant				

Usefulness

- What do you think about learning cognitive empathy through VR?

Perspectives

- How did you feel about the change of perspectives (fade-out/in, camera movement)?
- Which do you like better: fade-out/in or camera movement?
  - Fade-out/in
  - Camera movement

Appendix 2: Interview questions

Perspectives

- Does changing perspective between 3rd person and 1st person feel appropriate for this content? If it's not appropriate, why do you think so?
- Did you feel any difference between the 3rd person and 1st person perspectives? Did you notice anything odd, like cybersickness or awkwardness?
- Does the 1st person perspective feel appropriate for this content? If it's not appropriate, why do you think so?
- Which one do you think is more appropriate: changing the perspective or fixed (1st person) perspective? Why do you think so?

Gameplay and content

- What was the most uncomfortable thing about handling the VR devices?
- What was difficult or uncomfortable about this content?
- What did you like about this content?
- What did you not like about this content?
- What did you learn from this content?
- Do you think this game is suitable for children to learn empathy? Why do you think so?
- Which exhbition method (gallery, conveyor belt) did you find most interesting and why?

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Data availability The datasets generated during and/or analyzed during the current study are available from the first author on reasonable request.

Declarations

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Conflict of interest None.

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