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Embodied Gesture Interactions for a VR-based Commemorative History Game

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Abstract: This paper presents a system that implements embodied virtual gestures for a persuasive commemorative history escape room game in VR. The high fidelity of the virtual gestures to real-world gestures are guided in principle by the assertion that high action embodiment may elicit a higher emotional response to the intended learning objectives. The technical design of the system is discussed vis-à-vis the relevant embodied cognition principles. A preliminary user test was held where observational results and freeform user commentary were collected, to help finetune the system and to assess the potential effectiveness of the system as a learning tool for commemorative history with controversial topics.

Keywords: Virtual Reality, Embodied Cognition, Philippine History

1. Introduction

Embodied Cognition (EC) is the cognitive science theory that suggests that a person's cognitive processes are deeply intertwined with the person's physical body (Shapiro, 2019). Much work has been done to relate EC with effective learning, such as the idea that learning is more efficiently achieved if the bodily movement is meaningfully integrated into the learning task (Skulmowski & Rey, 2018).

Riva (2008) contends that Virtual Reality (VR) is a potential means to achieve this said integration, if embodied activities are meaningfully designed. A potential way to design a VR environment that promotes EC learning is to take advantage of VR's capability both to situate the user in a virtual environment and to allow the user to realistically simulate actions that would be performed in the real world within this virtual world, such as real hand and arm gestures as opposed to pointing and clicking in desktop computer games. Nonetheless, one must take care that the actions in this virtual world are highly integrated with the learning objective, i.e., are not there for the sake of increasing the user's physical movement but actually immerse the user more in the learning activity.

This paper explores a potential application of VR and EC in a non-conventional learning scenario: the commemoration of the history of Martial Law in the Philippines. This topic is deemed highly controversial, with bad actors spreading false information and necessitating fact-checking (Juego, 2022; Lanzona et al., 2017). Thus, a learning system that discusses the topic could get highly emotional, falling under the realm of persuasive media (Dolhalit & Salam, 2014). This implies that eliciting an appropriate emotional response from the learner may be as important as the learning objective itself.

Thus, our study will center on discussing this proposed learning system, applying relevant theories of EC to its construction. The system takes the form of an educational escape room (EER) game, where the achievement of learning objectives coincides with the player solving a multitude of puzzles to escape a virtual room. The next section will discuss system design, delving into EC theories and technical implementation. This is followed by a section discussing a preliminary user test to determine whether players using the system can achieve the intended learning objectives. The paper concludes with potential future work that would

delve deeper into the effectiveness of embodied cognition theory with these types of commemorative history applications.

2. Study Framework and System Design

The following treatise on our escape room game's design is divided into six subsections. First, we shall discuss embodied cognition principles in the literature that motivate the implementation of our gesture-based interaction system. Second, we describe the game itself and its core mechanics. This is followed by descriptions of the game's virtual facilitation features, an overview of the escape room puzzles in the game, a technical discussion of how the individual gesture interactions are implemented, and, finally, a discussion of the key collectible items in the game that double as the main learning objectives of the experience.

2.1 EC Principles Guiding Game Development

Many studies have explored the use of VR technology to enact embodied learning. A systematic review (Chen et al., 2023) found 125 papers on virtual embodied learning that focus on contextualization (use of EC in actual learning scenarios), conceptualization (understanding of components of EC), and causal link studies (investigation of how EC generates learning effects in scenarios).

This present study focuses mainly on the contextualization aspect, as it explores the use of embodied interactions in a persuasive game about learning controversial commemorative history topics, of which there is a dearth in availability (Kazlauskaitė, 2023; Mulders et al., 2025). These previous studies did find that the VR aspect imbues a sense of embodiment as they place the user as a semi-active participant in their narrative. However, their implementations are currently limited to non-interactive or semi-interactive modalities, either through the use of fully autonomous 360-degree video (Kazlauskaitė, 2023) or through simple point-and-click mechanics to move the narrative forward (Mulders et al., 2025).

Our study specifically considers more interactive user gestures to increase the immersion aspect of the learning experience. This is inspired by causal link research that suggests that users experience higher levels of valence, arousal, and dominance in reaction to emotional stimuli when in a high-embodiment condition versus in a low-embodiment condition (Gall et al., 2021). This aspect may prove to be beneficial to commemorative history learning, as the learning objectives tend to be highly emotional in nature (such as discovering human rights atrocities or exposing government corruption). There may be concerns about imposing additional cognitive load on students through the use of high-immersion media such as VR versus simpler reading activities, but preliminary research has reported similar cognitive loads when comparing such activities (Kaplan-Rakowski & Gruber, 2024), and the enhanced motivation and presence may offset any cognitive disadvantages.

2.2 Game Description

The game to be discussed in this present study is named *Heritage Hero: Secrets of the 'Golden Era'*. This game is developed using our escape room system called AVRE or Ateneo Virtual Reality Escape, which is a development framework built on top of the Godot engine and uses the standard Meta Quest 2/3 headset and controller configuration (Vidal et al., 2024).

In *'Golden Era'*, the player plays the role of an investigative journalist whose aim is to find the truth about the Martial Law era of the Philippines. The player finds themselves in the abandoned mansion of a Marcos crony, where they can look for evidence and find a way to print a document of their findings. The historical facts that players discover in the game are derived from first hand sources and learning resources collected by the Ateneo Martial Law Museum and Library (AMLML) (Lanzona et al., 2017).

The game has two major mechanics: The *escape room game* element, where the player solves puzzles to eventually print the document and leave the house, and the *information gathering* element, where the player looks for pertinent information regarding certain propaganda newspaper headlines that the player seeks to learn more about. These two

components come together at the end of the game, when the player prints the article based on the information the player was able to find. These two mechanics are supplemented by several core features meant to aid the player through the experience, which are described in the next section.

2.3 Facilitation Features

Physical educational escape room games usually employ a human facilitator to aid the player and to maintain focus on the learning objectives. In place of active facilitation, our VR game implements gameplay features to help users explore the abandoned mansion. These are the *journal*, the *inventory system*, and the *flashlight-radio*.

The **journal** contains a task log that shows the ongoing tasks that the player needs to accomplish. This log is updated every time the player gets a new task and when the player completes a task. The other journal pages are newspaper headlines that serve as positive propaganda for the Marcos administration. Whenever the player accomplishes one of several learning objectives (discussed in a later section), those pages are updated with the latest information that the player has found. Furthermore, the journal is implemented with directional swipe actions to let the player go to the next or previous page by swiping left or right, respectively, mimicking the actions of a real journalist flipping through their notes and increasing the player's virtual embodiment as they go through the investigation process within the mansion.

Figure 1. Journal in action. Left to right: task log, swipe to turn pages, newspaper headlines.

The **inventory system** has six grid slots that the player can store items in. The developers opted for the simple approach of using a grid system instead of a real-world-like representation (e.g., a virtual knapsack or wrist-attached system), as we found during preliminary tests (Ko et al., 2023) that such a system is more cumbersome to interact with and reduces the speed of the player when sorting through their inventory items, which could potentially lead to player frustration. One of these inventory slots is dedicated to the journal, so effectively, the player has five slots to use. When the inventory is toggled on via the assigned controller button, it will remain within the player's view, following the player's view until it is toggled off.

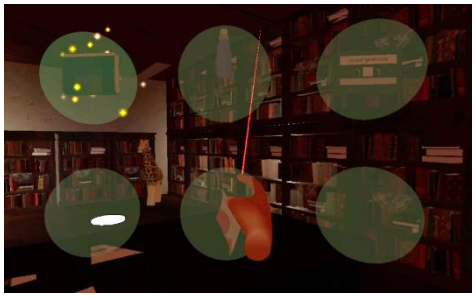

Figure 2. Inventory system in action. Journal is shown on the top left.

The **flashlight-radio** serves as both a light source and a hint system. The flashlight constantly shines light in front of the player when it is not being held, but if the player wants to shine light on more specific areas, the player can grab the flashlight to manipulate it freely. The flashlight also features a crank that, when rotated three times, will play a hint about the player's current objective. The hint is played in the style of 1970s – 1980s Philippine radio

broadcasts, with voice acting and music commonly heard during the historical period, helping in the player's imaginative embodiment of the time period. These hints do not outright tell the player the solution to the current puzzle, but they should give enough information through keywords to solve the puzzle. An example of a hint is a mock-advertisement of a detergent that can be safely sprayed on household objects, cluing the player in on how to clean a soiled painting in the mansion. This hint is given at the most appropriate time, as dictated by the tasks already accomplished by the player beforehand, making the player feel that they progressively discovered the solution themselves instead of being spoon-fed to them.

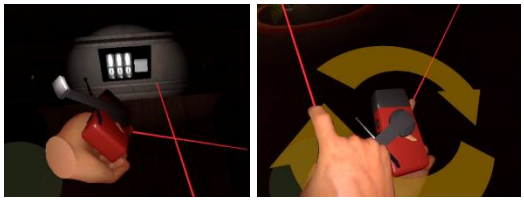

Figure 3. Flashlight-radio in action. Left: illumination function. Right: crank to use radio (hint).

2.4 Escape Room Puzzles

The three principal areas of the mansion, namely, the *study*, the *kitchen*, and the *bedroom*, each have unique puzzles (or minigames) to solve, all necessary to progress the narrative and clear the whole game. See Table 1 for a brief overview of these puzzles. The progression of the puzzles is non-linear, and the player is expected to navigate between these areas to find the necessary items.

Table 1. *Puzzle Distribution of the Heritage Hero: Secrets of the 'Golden Era' Game*

Area	Puzzles	Brief Description
Study	Piece together a document	Scattered pieces of a document that would lead the player to the next task are strewn around on a table and the player reconstructs the document.
	Clean a historical painting	Player locates a painting with significant propaganda value ("Malakas at Maganda") somewhere in the mansion and cleans it to reveal a code.
	Open the Study Desk's Drawer	Code from previous puzzle is used to open a drawer that contains a recipe for baking Nutribuns (used in a health program of the Marcoses) and a key to gain access to a printing machine.
Kitchen	Look for baking ingredients	Hidden in plain view around the mansion are the ingredients detailed in the Nutribun recipe.
	Bake Nutribuns	Follow the recipe in a strict order to obtain fresh Nutribuns. This involves making the dough, splitting the dough into four pieces, and baking them in the kitchen oven.
	Package Nutribuns	Baked goods are placed in packaging that heavily promotes Marcos's involvement in the Nutribun feeding program; player discovers a roll of paper that can be used in the printing machine.
Bedroom	Find a way into the Bedroom	The bedroom door is blocked from the other side preventing entrance from there. Player finds a hole in the wall of the study covered by planks. Player can break through the wall with a crowbar found near the kitchen.
	Match images to blueprints	Player matches photos of well-known Marcos-initiated construction projects to their original blueprints. Putting them in the correct order reveals a code.
	Find crony contracts	Code from previous puzzle opens a safe that contains confidential contracts, and the player must figure out the correct crony to open a suspicious briefcase.
	Open the crony's briefcase	Briefcase contains a component that allows for the operation of the printing press.
Study (ending)	Operate the printing press	The player uses the keys from the previous areas to jump-start the printing press and print a report about the 'Golden Era' based on the information the player learns throughout the game.

2.5 Object Interaction System

To support the actual user interactions to play the puzzles, an object interaction system (henceforth referred to as OIS) using hand controller tracking was implemented. This system allows the player to interact with objects by performing specific motions with their hands in combination with the grip and/or trigger buttons on the controller, to make the game more immersive and better mimic players' physical embodiment of performing the said actions.

The object interaction system is based on previous work (Lee et al., 2023) and has two major components: *actors*, objects that can perform actions, and *receivers*, objects that receive actions. Actors can interact with receivers that share the same group as the actors. Actors can perform any action as long as they are in contact with a receiver, but receivers are only able to receive particular actions. These actions are used throughout the game to interact with the game's world and to solve puzzles.

See Table 2 for which action is used for which interaction in the game. In general, the player uses the grip button to pick up an actor object, then performs one of the following actions to interact with itself or with receiver objects:

- The **wipe** action is performed by moving the actor object in any direction with sufficient speed while in contact with the receiver. This minimum speed value can be adjusted to change the sensitivity of the wipe action.
- The **twist** action is performed by rotating the actor object along a specified axis on the receiver. This rotation can be set clockwise or counterclockwise. Another setting allows for progress to be recorded only if the twisting action is performed in the correct direction. If the setting is turned off, the player can make negative progress by twisting in the opposite direction.
- The **strike** action is performed by quickly swinging the actor object towards the receiver. The action is registered when the actor is close enough to the receiver when the swinging action has ended. This distance can be set by the developer to allow for short-distance or long-distance strike actions.
- The **crank** action is performed by moving the actor object around the receiver's axis. Like the twist action, the direction of the cranking action can be set clockwise or counterclockwise, and there is a setting to allow for progress to be recorded only when the direction of the crank action is correct. A 3D vector determines the axis along which the cranking action can be performed.
- The **directional swipe** action is essentially the same as the wipe action but locked in a single direction. A 3D vector determines the direction the action is to be performed.
- The **attach** action is performed by putting two compatible objects close to each other and pressing the trigger on both controllers. The two objects will then be removed and replaced by a single combined object.
- The **detach** action is performed by grabbing an object with both hands and pulling both hands apart. This replaces the single object with two objects, one in each of the player's hands. This action can be set so that detaching the object will only work when the triggers on both controllers are held.

Table 2. *OIS Actions used for In-game Interactions.*

OIS Action	In-Game Interaction
Wipe Action	Wiping a painting clean with a rag
	Mixing and kneading bread dough
Twist Action	Turning a key inside a lock
	Turning the oven on
Strike Action	Hitting the planks on the wall with a crowbar
Crank Action	Operating the radio part of the flashlight radio
Directional Swipe Action	Swiping left-to-right and right-to-left to navigate the journal
	Opening and closing the oven

Attach Action	Attaching torn pieces of paper to complete a document
Detach Action	Detaching individual buns from a large piece of dough

2.6 Collection of Key Items as Embodiment of Learning Objectives

The game scope is not limited to just solving all the puzzles; the game also makes the player look for certain key items to move the investigation forward. There are seven key items within the game, and each of these is related to one of the propaganda newspaper headlines found in the player's journal. Near these key items are cassette tapes that explain the truth about these key items.

To use the cassette tape, the player must place it into a cassette player and press a button on the player to hear the audio (with subtitles shown in front of the player's view to assist people who are hard of hearing). When the cassette has finished playing, the information given by the tape will be found in the player's journal. The virtual action of operating and listening to the cassette player is meant to increase the player's sense of embodiment and emotional response (Gall et al., 2021) as they hear the information on the cassette tape.

At the end of the game, when the player prints the article, only the information that the player has found via the cassette tapes will be printed out. While it is possible to play through the game and print nothing at all by the end, playing these cassette tapes serves as a collection mechanic that encourages replayability of the game. Having the content within the cassette tapes reiterated in the player's journal and the printed article also helps solidify the intended learning objectives of the game.

Figure 4. Inserting a cassette into the cassette player to play the information within.

3. User Testing

A preliminary user test was held to evaluate the alpha version of the Heritage Hero game. This alpha version implements all the user gestures and interactions documented in the previous section, although the game's educational content was not 100% complete at the time of testing. While this user test was aimed primarily to assess the overall usability of the game through usability questionnaires (details of which were presented in an earlier paper), this test also included: (1) observations of the participants' execution of the interactive gestures, to assess whether they could easily perform the actions or if they are having difficulties, and (2) user-provided feedback with regards to gameplay mechanics and immersion in the experience, which would provide some insight to the effectiveness of the embodied cognition principles that were implemented.

The participants were composed of Ateneo de Manila University students from various year levels (1st: 1, 2nd: 11, 3rd: 1, 4th: 1), ages (19.86 ± 0.86), and genders (8 males, 4 females, and 2 non-binary). The research protocol was submitted to and approved by Ateneo's University Research Ethics Office.

3.1 User observations

The main portion of the user test involves the participants playing the VR game from start to finish. The developers observe and take notes of any difficulties encountered while each participant is playing, providing only the minimal intervention necessary to allow participants to proceed with the game. These observations are mostly used to inform the implementation of engine fixes to achieve a smoother gameplay experience for the final release of the game.

It was found that most participants had difficulties in similar places within the alpha version of the game, pointing to specific implementation issues rather than general system flaws. The crucial issues found are: players not using the flashlight and journal effectively, difficulty with splitting the dough into four pieces, and turning the oven on.

The first issue, tied to the flashlight, is caused by the original implementation requiring the user to hold the flashlight at all times, which the participants are unaccustomed to. This led to some complaints about the game being too dark, and the action could hinder the rest of the gameplay, as it leaves the player with only one free hand. As a fix, the flashlight is changed to always be turned on and facing forward, even if the player is not holding it. This allows the player to always have light in the general direction where they are looking and still keep the dark atmosphere of the game. If the player wants to see something in particular, they can grab the flashlight and freely point it wherever they want to. While this fix can be seen as a downgrade to the embodiment of the action of exploration, it can be argued that the illumination action originally does not fully align with the user's learning objective, and that users do not necessarily need to produce the entire action to achieve the desired learning (Alibali & Nathan, 2018).

The second issue, not using the journal, also meant that the players did not know what to do next. This is fixed by showing an explicit message in front of the player to tell them that journal entries are added or resolved, and the journal's inventory slot is highlighted to indicate added information (shown as "sparkles" on the journal item in Figure 2).

The third issue, about splitting the dough, was caused by two sub-issues. One, the dough-splitting gesture had the setting of holding both triggers to perform the split action turned on. This was found to be unintuitive for the players, so the players had to be informed by the test facilitators on how to do the action. Second, the setting for how far the controllers have to be moved apart was originally set to a high value, meaning that the players had to spread their arms open to split the dough. Both sub-issues were addressed by turning off the trigger action setting and by reducing the distance needed for the action to be registered.

The fourth issue, having a difficult time turning on the oven, affected the greatest number of players. The issue was that to rotate the oven's knobs, the hands had to be angled in a very awkward position where the hand had to be twisted up and rotated clockwise. To address this, adjustments were made to make the hand position less awkward, and the sensitivity of the action was increased.

3.2 Free-form assessment

After the gameplay session, the respondents were asked several free-form questions to help evaluate their game experience. To ease the process of analysis but still minimize potential bias, for each category of questions that we asked, we summarize the results in several tables to highlight whether their responses were positive (green), neutral/mixed (yellow), and negative (red). This analysis is divided into two subsections: comments on general gameplay and comments on users' perceived immersion into the game.

3.2.1 Gameplay: Interesting Features, Relevance of VR, Educational Value

The questions for gameplay are as follows.

(1) Relevance of VR: Do you think the Virtual Reality (VR) component of the game helped improve or worsen the overall experience? How did VR improve or worsen it?

(2) Educational Value: Do you have an opinion on the educational value of the game?

Several participants stated that the Virtual Reality (VR) component improved the overall experience primarily because of its immersive aspect. They become more engaged as it is interactive, educational, and fitting for a VR escape room. This allowed participants to learn

about the content as they progressed in the game. Some participants, however, felt some discomfort (e.g., fatigue, nausea) while playing the game due to technical issues. (The game was streamed from a PC to the headset.) Only one participant shared that they felt that the game could be made as a regular digital game and that it does not play to the strengths of the VR medium, although they also commented that the VR component enabled more freedom for the player.

The feedback on the educational value of the game was mixed. Some found that the content presented was sufficient (not overwhelming), but some found it lacking. They did acknowledge that they are playing an incomplete game, so they hope that more critical details about the Martial Law period will be included upon completion. Other suggestions focused on the game design: further improving the player's interaction with the objects/artifacts, increasing emphasis on the said artifacts' educational value, as well as the cohesion of the puzzles and the game narrative. We note that this finding actually points to users being able to easily digest the learning objectives that were already present in the game's early version and would like for more content to be included, which may, in turn, suggest that the embodied gesture interactions in the game were effective (though there were no direct measurements of the effect as of this testing).

Table 3. *Summary of Responses to Gameplay-Related Questions*

Relevance of VR	**Educational Value**
Improved (11)	Informative and flexible (7)
Both (2)	More historical information is needed (6)
No (1)	N/A (1)

3.2.2 Immersion: Affect, Intuition, and Persistence

The questions for immersion are as follows:
(1) Feeling: How did you feel when playing the game? Did you feel *scared, tense, or calm*?
(2) Sense of time: While you were playing, did you lose sense of time? Did the events seem to happen *normally, automatically, quickly*?
(3) Intuition: While you were playing, were your *thoughts quick*, did you *not think how to play*?
(4) Persistence: At some point, did you *want to stop playing*, or did you *want to continue playing*?

Most participants felt relaxed and calm overall while playing the game. Some reported being excited and even scared due to the atmosphere of the game, as the VR component effectively provided the environment and ambiance of an abandoned mansion. However, some participants shared that while they were calm, they were bothered by certain factors, such as the headset placement and elements in the real world. This may be due to the overlapping playing boundaries of participants since they tested the game simultaneously. It was observed that two players often clashed or hit one another while playing the game simultaneously during the user test. As a result, one participant felt tense as he played the game, and the other was somewhat bothered. Interestingly, one participant found the movement in the game restricting.

Aligned with participants' comments about the immersive aspect of the game, several stated that they lost their sense of time while playing. Some mentioned that events seemed to happen normally, while one felt like they happened quickly, and two participants felt that time was a bit slower. None of the participants shared any negative feelings related to these.

When it came to the intuitiveness of the controls, some players were quick to pick up how to play, while some struggled, both in figuring out the gesture controls initially and in remembering already-used gestures. They were unsure what steps to take and what actions or movements were possible in VR. Some fared well but needed time to adjust to the controls and mechanics of the game. It should be noted that facilitators were present during the play testing to help players with the game controls, but such help may not be forthcoming in more casual scenarios (e.g., a user playing the game on their own time).

Finally, many of the players wanted to continue playing the game and expressed that they wanted to finish it once the complete version is available. It piqued their interest and elicited a desire to learn more. Some players, though, shared that they wanted to take a break from playing due to physical and technical issues. One participant said they wanted to stop completely due to dizziness (although they voluntarily continued). It is important to note that some test instances were hampered by poor connectivity between the PC and headset, causing visual artifacts that can cause severe irritation and/or disorientation for some users. Nevertheless, all participants were able to finish the current game build during the user test, and they were given time to settle before answering the post-test questionnaires.

Table 4. *Summary of Responses to Immersion-Related Questions*

Feeling	Sense of Time	Intuition	Persistence
Relaxed, calm (7)	Yes, lost sense of time (8)	Yes, quick (5)	Wanted to continue (11)
Excited, scared, curious (4)	Events happened normally (4)	Slowed, had to think (5)	Wanted to continue but needed a break due to issues faced (2)
Mixed (3)	Time was a bit slower (2)	Needed time to adjust first (3)	Wanted to stop due to dizziness (1)
Tense (1)	Events seemed to happen quickly (1)		

4. Conclusions and Further Work

This paper describes the design and development of the gesture interaction system of our educational escape room game, Heritage Hero: Secrets of the 'Golden Era', for persuasive affective learning of commemorative history. The development of the game was guided by embodied cognition principles, leaning heavily on previous causal-link studies that recommend high immersion in reading activities (Kaplan-Rakowski & Gruber, 2024) and high embodiment of actions to intensify emotional responses (Gall et al., 2021), which led to developing a virtually-embodied gesture system with a high level of fidelity to their corresponding physically-embodied counterparts.

Preliminary user testing has shown promise in the effectiveness of imparting commemorative historical learning objectives through our system, as most users have demonstrated high immersion in the testing activity and indicated the desire to learn more content through the same system. However, this preliminary test has not established whether the game directly enhances learning outcomes and retention. To remedy this shortcoming, a follow-up user evaluation consisting of a standardized usability test as well as a post-test of learning objectives can be performed, alongside a control group that receives the same information via a different modality, e.g., directly perusing the AMLML resources referenced by the game (Lanzona et al., 2017).

Another limitation of the study is that while the physical gestures emulated within the game (wiping, twisting, etc.) provide high-embodiment immersion that helps in engagement, it may be argued that the tasks themselves are not yet shown to be highly integrated with the learning objectives in the traditional sense (Skulmowski & Rey, 2018). While the gestures immerse the player in activities typically performed by an investigative journalist, they may not directly engage the player's learning faculties, i.e., as embodied hand/finger gestures do for learning basic math concepts. However, it may also be argued that the affective learning aspect of these gestures is a mostly unexplored dimension that may have important effects for persuasive learning. Previous commemorative history studies report that even marginally increased kinesthetic embodiment via the use of VR may result in higher user susceptibility to emotionally charged content (Kazlauskaitė, 2023), which merits deeper examination.

Moreover, further work is necessary to establish whether this study's high-embodiment approach is significantly more effective compared to lower-embodiment learning scenarios, as seen in previous commemorative history VR experiences. Such work could conduct experimental tests with regard to measuring the user's emotional response to the learning

objectives. An effective test of emotional response to controversial learning objectives could manipulate factors on multiple participants with counterbalanced testing such as that performed by Gall et al. (2021) —for example, users can perform several trials with versions of the game with and without the cassette tape mechanic, and participant self-assessment can follow each trial to measure whether the emotional response to the learning objective was intensified.

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