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Melody Mystery: Learning Music Theory through Escape Room Puzzles

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Abstract: This paper explores the use of escape room puzzles and instructional scaffolding in teaching novice learners about basic music theory. This study used the notion of epistemic frames in games as the basis for its experiment, combined with the use of technology-based scaffolding. We examined how effective it is to engage and motivate novice learners when they are made to mimic the role of an expert in music and solve problems using their knowledge and skills in the subject. We found positive responses from participants' attitudes toward music theory and the ability to retain knowledge of the subject, as well as evidence which proves that games can have significant effects on motivation in the learning process.

Keywords: music; escape room; puzzle; music theory; epistemic frames

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1. Introduction

Music theory is essential for one to understand how a music piece is constructed. It is not only theoretical but also practical, providing the fundamentals for playing and composing music. For music learners, music theory poses a challenge due to its overflow of information and overly technical nature. It can leave some students with a bad experience of music education, which deters them from pursuing the subject altogether [1]. It can leave novice learners unmotivated, which is a challenge for educators.

Author [2] posed some challenges that hinder students from successfully learning music theory, one of which is their own specific characteristics, as some were "hands-on learner who struggled with theoretical material", while others lack interest and confidence in music theory. In the face of these types of challenge, one of the ways in which educators have been reinventing teaching methods is by gamification. Gamification can be defined as "use of game design elements in non-game contexts" [3]. It involves "mechanisms of games, aesthetics and thinking of the game to involve people, motivate action, promote learning and problem solving" [4], while in a non-leisure context [5].

This paper is authored by two high school students in Singapore under the supervision of a Senior Research Scientist at [blinded for review]. The paper describes an independent research project conceptualized and enacted by the students from April 2022 till December 2022. Institutional protocols constrained the independent research project in terms of its overall timeframe and non-funded nature. This—in turn—limited the scope of the project. Within these constraints, our target was to motivate these learners through becoming more purposeful and goal-oriented in their learning, using games as our medium.

We created an escape room with puzzles related to music theory using epistemic frames, which focus on ways of knowing through the lens of a community of practice [6]. Escape rooms are games in which players need to rely on information provided by their surroundings to solve puzzles, and ultimately to escape the environment. The end goal of our game is for the players to have a fundamental understanding of basic music concepts (notes, notations, scales, chords), expressed through their ability to identify the concepts and their roles. This is part of Singapore's O-Level assessment objectives for Music Studies,

which required students to "identify, explain and/or describe musical concepts" [7]. Players are also introduced to musical skills: reading and playing from a music sheet, and playing by ear (performing a piece of music they have heard but have not seen the notation of).

Educators have increasingly made use of escape rooms to improve both the engagement and learning process of students in recent times. Ref. [8] states that 30.9% of studies on escape rooms from 2009 to 2019 reported a gain in fundamental knowledge [9]. Improvement in students' motivation and engagement is also observed [9–11]. Thus, we are expecting positive learning practices and mindsets from the players during the game, including learning from experience and self-motivation.

In our game, Melody Mystery, we invited student-peers to take on the role of an expert in music and enforce this role by putting music theory concepts into context (puzzles) where students need to use musical knowledge and skills. We combined this with technology-based scaffolding, to observe how effective this method is regarding self-learning.

The remainder of this paper includes the concepts and theories on which we used to base the direction of our games, details of the escape room Melody Mystery, and the implications we were able to deduce from post-interviews with participants in the game.

1.1. Epistemic Frames

Epistemic frames are defined as "the ways of knowing with associated with particular communities of practice" [6], where "knowing with" is to understand a concept in "a context within which a particular situation is perceived, interpreted, and judged" [12].

Author [6] investigated two educational role-playing games. The first one involved a girl participating in Escher's World, "a role-playing game in which middle school students worked as graphic artists in a simulated, computer-aided design studio" [6] over the course of the summer. In the second game, The Pandora Project, students take on the role of a professional mediator to learn about human immunobiology and biomedical ethics. Author [6] highlighted the change in confidence and attitude towards the subjects, in a positive direction for both cases. The learners become more active and interested in the knowledge they were exposed to by the games, both inside and outside the classroom [6]. They also proved to be more comfortable with using technical expressions in the post-interviews and in their own classrooms. This proves that sufficiently rich experiences in technology-supported simulations of real-world practices may help students deal more effectively with situations in the real world and in school subjects beyond the scope of the interactive environment itself.

1.2. Technology-Based Scaffolding

Scaffolding is traditionally defined as:

> "... (a) process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts" [13].

A more detailed description of scaffolding is: 'dynamic interactions between a novice learner and an expert source of knowledge, whether an adult or a more experienced peer'. However, in modern times, the definition of scaffolding should be expanded to fit in with recent developments in the world. It is no longer limited to interactions between people, but it can also refer to technology-based tools [14]. These tools can offer support in terms of structure for a complicated task, providing leading cues and hints that guide learners in the correct solution, although it must be noted that they might not be able to offer live assessments of learners' skill levels and they are unable to detect when to retract their support system.

Effective scaffolding involves selecting a learning task that ensures that learners will need to use both skills that are within and beyond their ability, in which the latter can still be completed with assistance [13]. There is a need for the task to be engaging and interesting enough so that it keeps the learners involved [15]. It is also important that the creator of tasks must anticipate errors that learners might possibly make during the solving process to refocus the learner's line of thinking back in the right direction [16].

1.3. Motivation Mechanism in Games and Educational Settings

It can be seen that setting goals can benefit a learner's motivation in moving forward in a task [17]. Games and the learning process have the same concept as goals. In games, goals drive the player's progress. In learning, goals are the knowledge and skills obtained, or excellent performance in academic assessments [18]. Thus, the goal can be an ultimate prize at the end of the learning process, or a side achievement as the learners go along the way. Specific, difficult goals can be linked to motivation and engagement in learners [19,20].

Author [21] has proposed that good game mechanics can be linked to good learning principles. The nature of good games, "remaining challenging, but do-able", leads to a "pleasantly frustrating" state in players. [21]. An ideally challenging game can engage a learner's self-esteem, which makes it "intrinsically motivating" [22]. Overall, letting students tackle a challenged puzzle can elicit their engagement in the puzzle-solving process, and, subsequently, their motivation to learn 'how to' [23].

Moreover, good games find ways to put relevant information inside the game and make it explicit that they are useful to the players' goals. This encourages immediate understanding and remembering of the contents learned, unlike in schools, where knowledge can be "out of the contexts of actual use" [21]. Author [21] also suggested that the game offers a glimpse into how certain identities and roles within subjects are constructed, which can further motivate learners to dive deep into these topics. This is congruent with the epistemic frames previously mentioned, which also focus on shaping learners' identity as experts, in hope of those experiences transferring to the real world.

2. Materials and Methods

The aim of this paper was to explore how epistemic games can strengthen learner motivation and engagement, perhaps as a prelude to more explicit and didactic instruction in the respective domain-specific knowledge. In author [6]'s research, games involve the learners acting out professions that involve both relevant and irrelevant content to their academic subjects. This paper focuses on the effectiveness of epistemic games that are built around more school-focused content, assisted by technology-based scaffolding.

2.1. Participant Profiles and Logistics

An exploratory case study approach [24] was conducted on two participants, R & G. We decided on this method based on what we sought to understand—why and how gamification, more specifically escape rooms, affects learner motivation and learning ability. Methodologically, qualitative methods are used when the focus of the investigation is to gain a deeper understanding of the perceptions of people regarding a particular phenomenon [25]. In the case of the study reported, the phenomenon is the use of a bespoke game modelled on escape rooms as an introduction to music theory. Author [24] has described qualitative research as collecting data from a variety of resources, evaluating the data, analyzing evaluations to produce findings, and presenting the findings. According to Author [26], in case study research, the researcher explores a "real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information" (p. 97).

Because of the non-funded nature of the intervention, participants were identified through convenience and drawn from the social peers of the student-authors. Students participating in this research were novice learners of music, with little to no knowledge of the subject. Two students between 16 and 17 years of age were sent the game and instructed to play them individually in Zoom calls with the student researchers. All of the sessions were one-on-one. The participants were allowed to ask for clarifications and assistance relating to the mechanics of the game during the session. They were asked questions about their music background before the session.

From the pre-interview, the general consensus among the participants was that music theory was difficult to understand. Both participants rated the difficulty as 4 out of 5, with 1 being easy and 5 being extremely difficult.

The escape room, Melody Mystery, was made and conducted using Scratch, which is a service built around a block-based visual programming language and developed by the MIT Media Lab (Cambridge, MA, USA). Puzzles in the form of escape rooms were used due to their role-playing elements, which could aid in the process of helping students mimic their roles as experts.

2.2. Escape Room Puzzles

The participants were identified as novice learners with little or no knowledge of music. Thus, the escape room made use of scaffolding to aid them in completing the puzzles and constructing their identity as an expert. The knowledge and skills applied in the puzzles are taken from Music GCE O-Level Syllabus 6085 [7].

The escape areas were divided into four rooms. Participants were required to complete all puzzles in each room to proceed to the next one. There were two interactive learning activities and five puzzles in total. Each room came with an information button in the top left corner for players to revisit the instructions of the rooms at any time. Any music concepts mentioned in the game were deliberately not defined, for the sake of students' self-exploration.

A letter was shown at the beginning to introduce the game content and to enforce the role-playing element (Figure 1). It addressed the learner as "musician" and set up a "quest" of finding the treasure to instill a sense of curiosity and excitement, as well as explicitly putting them in the role of an expert in music.

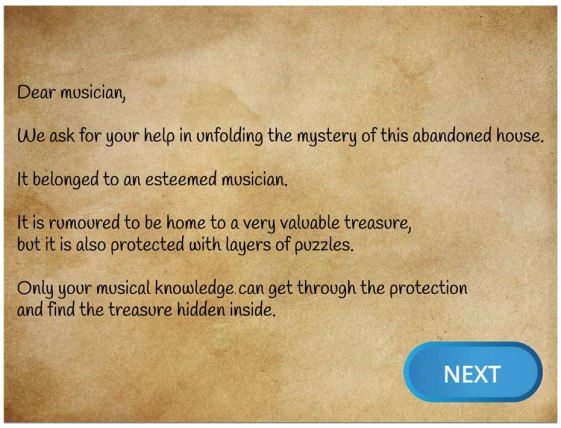

Figure 1. Introductory screen of the game.

The first room focused on the basics of natural musical notes. Activity 1 introduced musical note symbols, their notations on a musical score, and their position on the piano. This is shown in Figure 2; the arrows in the user interface allow the player to move backward and forward through the practice puzzles within the activity.

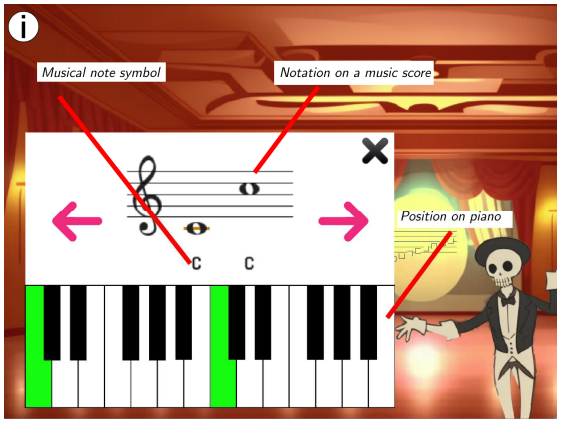

Figure 2. Activity 1: A skeleton introducing musical notes and how to identify them.

Puzzle 1—within Activity 1—required participants to put paintings of the musical notes back in their correct position on the wall. This was used to reinforce the knowledge the participants had learned about musical scores and the positions of each note, ensuring that they could approach the next puzzle with more confidence. This is shown in Figure 3; also visible in the figure is an arrow at the top-left of the user interface to allow the player to return to the top-level of Activity 1.

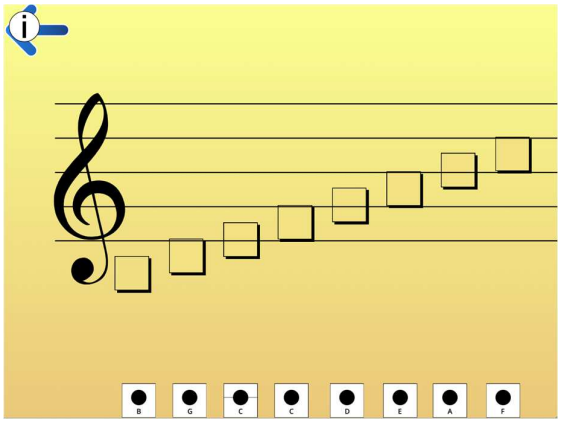

Figure 3. The initial screen of Puzzle 1.

Puzzle 2 required learners to play from the score 'Canon in C' on the virtual piano by clicking on the notes. This is shown in Figure 4; also visible in the figure is an arrow at the top-left of the user interface to allow the player to return to the top-level of the activity. They were given 20 s in-between notes to decide their next moves. If they were too slow or made a mistake they would be asked to restart. This puzzle enabled participants to apply what they had learned from Activity 1 to navigating a musical score.

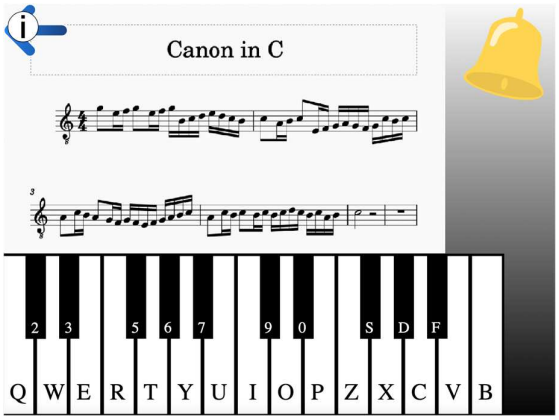

Figure 4. Puzzle 1: A virtual piano and the music score of *Canon in C*.

The second room introduced the concept of flats and sharps. Figure 5 shows the opening screen as presented to the player.

Figure 5. Second puzzle room: hall—including stairs, a phonograph, and a piano.

Activity 2 therefore depicted a musical staircase, which presented these notes as one "step" lower or higher than natural notes by rendering the keys of the piano diagonally instead of horizontally. We also used the "+" and "−" symbols to suggest the increase and decrease in the tone of the note (Figure 6). No explicit description was given to allow learners full liberty to explore the concept.

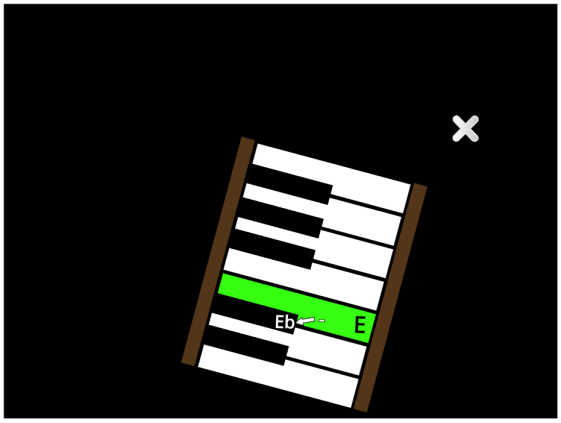

Figure 6. Activity 2: Musical staircase displaying natural E note, and flat E (Eb).

Puzzle 3 required the participants to use the virtual piano (Figure 7a) to repeat the melody they could hear when they clicked the phonograph (Figure 5). We used Beethoven's 5th Symphony as the melody, slightly more challenging than Puzzle 2 because it includes flats. They are also given the option to open up the music sheet and play along once they had made three failed attempts (Figure 7b,c). The learners are not informed of this support mechanism to avoid them deliberately making mistakes to access the puzzle instead of experimenting with the phonograph. The music score poses a new challenge to them as they are required to analyze and understand what the three flat symbols at the beginning of the score meant (every note in the same line as the symbols must be a flat note). This puzzle introduces them to ear-training, a musician's skill by which they identify basic elements of music, such as notes.

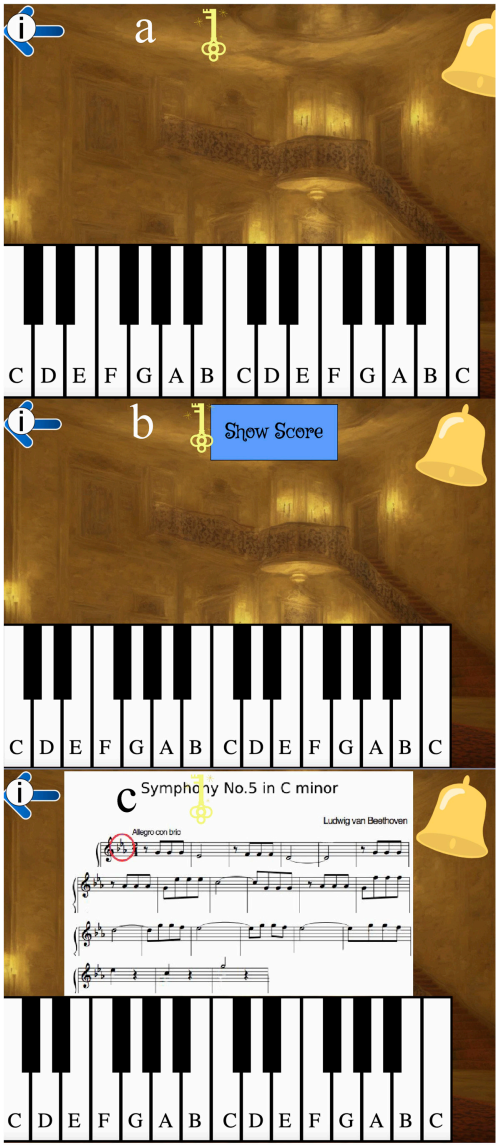

Figure 7. (top to bottom) (**a**) The interface of Puzzle 3 (**b**) "Show score" button appears (**c**) "Symphony No. 5" score, with the flats symbol circled in red.

The third room focused on scales, which are different orders of pitches. Figure 8 shows the opening screen as presented to the player.

Figure 8. Third puzzle room: Lounge.

Activity 3 was a jukebox that could be interacted with to play the same tune, the piano version of Louis Armstrong's 'What A Wonderful World', in different scales using buttons. This is depicted in Figure 9, in which the symbol for each scale was on a button. The scales were arranged from high to low. Participants could listen to the song in different scales by pressing buttons on the left jukebox and start the puzzle by pressing the play button on the right-hand jukebox.

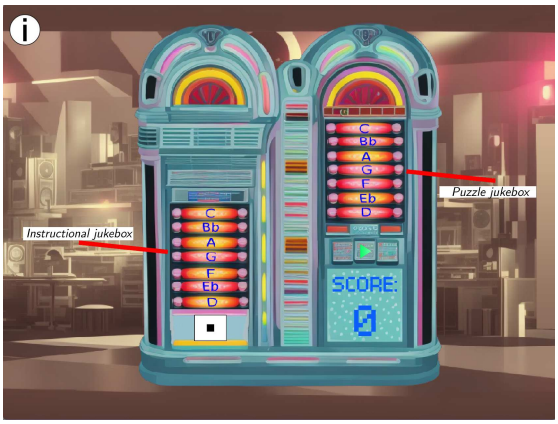

Figure 9. Instructional jukebox and puzzle jukebox.

Puzzle 4 required participants to identify the correct scale of the tune being played. They were to correctly identify all seven tunes being played in order to proceed to the next room. The puzzle was another form of ear training and a lesson in recognizing different scales. It also allowed the participants to explore and develop their own definition of scales.

The fourth room focused on chords, which are three or more notes played together. The melody played was the vocal version of the song 'Driver's License' by Olivia Rodrigo. Puzzle 5 required participants to press the correct buttons labelled with chords that match the flow of the audio being played. There was a launch pad with six buttons, each button representing a different chord, as depicted in Figure 10.

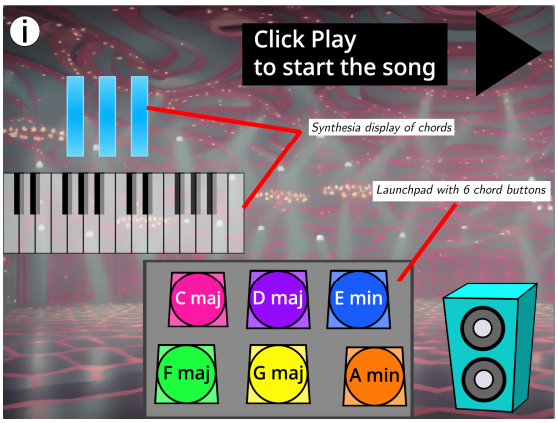

Figure 10. DJ puzzle and its components.

A synesthesia display—which is a playing keyboard timed to a MIDI file—of the three notes of each chord would appear in a correct sequence to show what chords were to be pressed and when to press them. Two mistakes were allowed in each play; if the players made more than two mistakes, they would need to start again. If the learner failed to play the correct sequence four times, the synesthesia would appear in the same color as the chord buttons to assist them. While this prevented the learner from trying out the activity as many times as they could, we wanted to ensure the learner could observe the correct chords when they were unable to guess the correct sequence. This was to explore how the learner could still obtain knowledge even if they did not complete the puzzle in the

intended way. This puzzle allowed learners to explore chords' function in a song and develop their own perception of the musical element.

2.3. Survey Questions

After completing each puzzle, participants were invited to respond to the following open-ended questions:

1. Do you feel accomplished and motivated after finishing each puzzle and the game as a whole?
2. What was your strategy for each puzzle?
3. How helpful do you find the learning activities and the extra help given when you are unable to complete a task?
4. What do you understand about these symbols: # and b?
5. What do you think is the purpose of scale in music?
6. What is your definition of chords? What is their purpose?
7. Do you feel like you can navigate these scenarios? Elaborate.

   Scenarios:

   a. reading and understanding musical scores
   b. interact with the piano

8. What do you feel is the most effective part of the game that contributed to your learning?
9. Compared to before playing the game, do you feel more comfortable learning music theory?
10. What do you think we can improve in the gameplay? What systems do you want to see introduced in the game?

3. Results

In this section, we examine the effect of our game on the participants' motivation, engagement, and perception of music theory. The participants are referred to as R and G, respectively, and their responses will be numbered for easier referencing.

In response to question 1: "Do you feel accomplished and motivated after finishing each puzzle and the game as a whole?", both participants agreed that completing a puzzle offers a sense of accomplishment that encourages them to continue the game. This was reflected in their responses.

Both expressed that their initial progress was slow as they became familiarized with the puzzles and their mechanics, but they also found strategies and methods to solve the puzzles, utilizing the resources provided. While R's response shows satisfaction as a driving factor after completing a puzzle, G's response shows a goal-oriented mindset.

Question 2 reveals the way the players were able to come up with strategies to approach the musical puzzles. Some notable strategies were similar to the methods of real-life musicians, implying that participants were taking on their role as an expert in their way of thinking.

Both participants did some form of note-taking to assist them through Puzzle 2 and Puzzle 3.

For Puzzle 2, G wrote down all the musical notes from C to B on paper from memory (Figure 11) and used that to compare with the notes he saw on the screen in order to slowly find the correct key. On the other hand, R found the correct sequence by counting from the previous notes on the music score and from its key, simultaneously, in order to reach the next key.

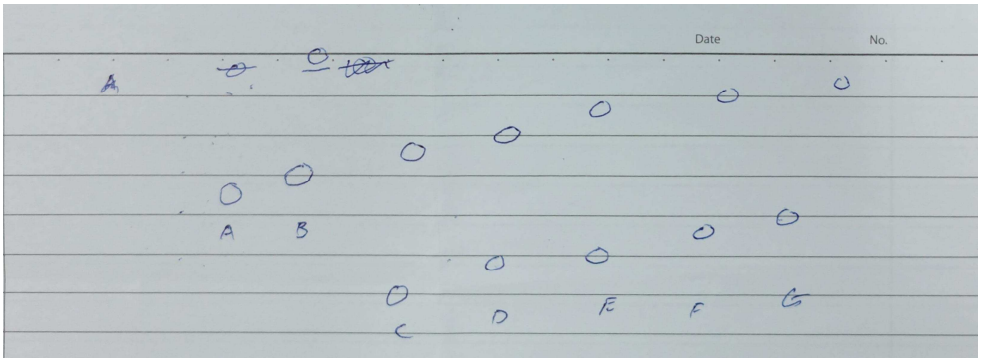

Figure 11. Participant G's notes for Puzzle 2.

For Puzzle 3, R listened to the melody played, found three to four correct notes on the keyboard, and noted them down (Figure 12). This cycle was repeated until he could play the whole melody correctly. As seen in Figure 12 below, R correctly annotated the melody with flats and sharps symbols.

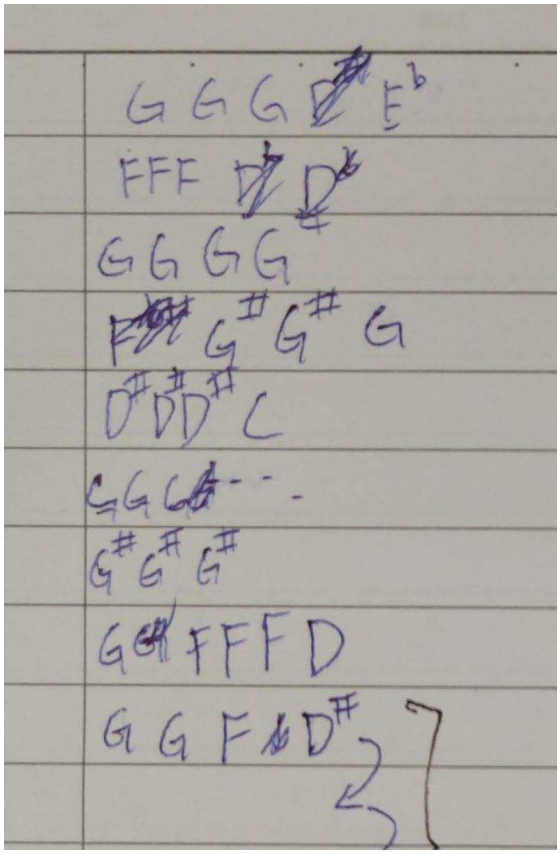

Figure 12. Participant R's notes for Puzzle 3.

Participant G chose to see the music score but had a similar strategy. He spent around 15–20 min dissecting the music score and had to resort to asking the help of the student researcher for a hint. When he understood the pattern, he noted the symbol for the notes down, along with other appropriate symbols, to ensure he could play without any mistakes (Figure 13).

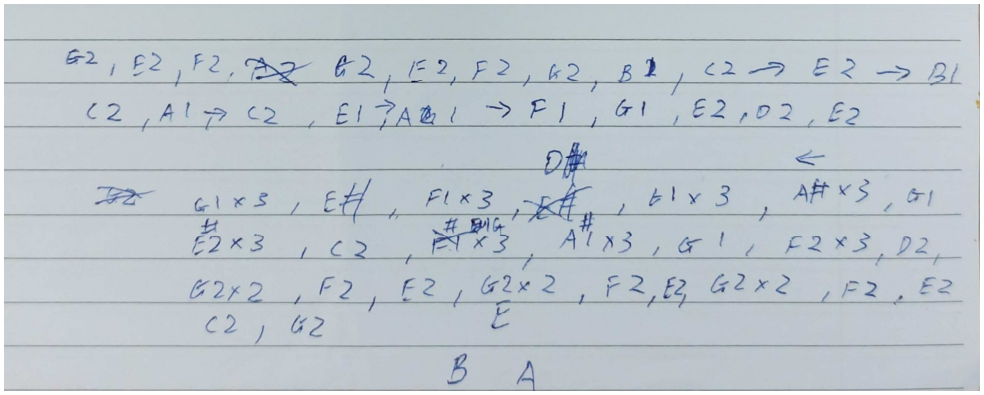

Figure 13. Participant G's notes for Puzzle 3.

Participant R made faster progress than G, but both were able to complete the puzzle by using the annotation method, similar to what musicians do when they want to understand and play a piece well.

As can be seen in Table 1 Participant R was able to come up with a strategy when he played around with the instructional jukebox and discovered that the scales were increasing in pitch.

Table 1. Participants' responses to Question 2.

Participants' Response	Content
R2	"You have the higher end and the lower end, if you get (remember) the center melody that is played, if you hear higher (than the center melody) you choose the upper part, then determine whether it's closer to the higher end or middle, same with lower end."
G2	"The first button was pure guessing, but then I used it as an anchor too. After a while I actually memorized some of the melody and I could correctly guess them straight away."

To explain his method in more technical terms, Participant R compared the pitch between the scales he could remember and the scale being played to determine the correct answer. Although he lacked the vocabulary to explain it, he clearly had no problem figuring out this approach, completing the game in one try. G also did something similar in his response G2, although he had to struggle more in the beginning in order to guess the correct scale.

To investigate how effective the scaffolding was in our game, we sought feedback on the learning activities and extra help given when the player experienced difficulty in completing the puzzle in question 3.

Participant R found the Learning Activity helpful as it provided exactly what he needed while solving the puzzles. G, on the other hand, was appreciative of the support and hints given when he struggled with Puzzle 3 and Puzzle 5, which allowed him to complete the experience of playing the game without building up too much frustration.

Notable reactions are found when the third puzzle presents the players with the option to open the score in Puzzle 3, when they make three failed attempts to complete the puzzle, in order to assist them.

Participant R ignored the option and continued with his strategy to complete the puzzle. When asked, he explained that he would feel more satisfied if he were to finish it using his own way.

On the other hand, Participant G immediately looked to the help of the score.

We also investigated how participants form their own perceptions of music theory concepts, including flats, sharps, scales, and chords through questions 4, 5, and 6.

Participants R and G show a good understanding of what flat and sharp notes are. R went one step further and was able to identify that the difference between them and natural notes is "half a note", as seen in his response below.

Another artifact was the written notes made by participants to help them navigate the puzzles better (Figures 12 and 13). Both Participants R and G used the symbols of flats and sharps that they learned from Activity 2 to annotate, showing skill in identifying notes and a level of comfort in using their newly acquired knowledge.

As seen from Table 2 both participants can give what they perceived to be definitions of the scales (R5 & G5) and chords (R6 & R6), and even their functions. Participant R could even infer that the use of scales was a way to set the mood for a song when he observed the difference in tones between scales, not just pitches.

Table 2. Participants' responses to Questions 5 and 6.

Participants' Response	Content
R5	"Different scales can affect different moods of songs. Like this one is happy, this one sounds gloomy."
G5	"Scales got high got low ah."
R6	"Three notes, wait, maybe more than three notes, played together. They're like the background (of a song) right?"
G6	"Multiple notes together (. . .) In a song, chords make it sound more layered."

Question 7 assessed whether the learners felt confident enough to apply the knowledge and skills learned from the game in real scenarios. In the hypothetical scenario where they needed to read and identify musical notes on a score, both participants expressed comfort in doing so. In the second scenario, they were more reluctant about their ability to identify the correct notes on a physical piano keyboard. Participant R's reason was that he only ever used the virtual keyboard in-game and has never interacted with a physical one.

To uncover the effectiveness of the game's other features that we might not be aware of, we asked the participants about their favorite part of the game.

Participant R expressed a liking for the flow of the game and how the difficulty in content and skills increases slowly over time.

We asked similar questions before and after the game to analyze the change in participants' attitude toward learning music theory.

As stated, the participants initially considered music theory to be at a high difficulty level, and they provided reasons (Question 0). At the end of the game, when asked about whether their attitude towards learning music theory had changed (Question 9), there was an improvement in their perception of the subject (Question 9).

Compared to before they experienced the game, both participants showed an increase not only in confidence in their ability to understand music theory, but one of them also expressed his wish to delve deeper into the topic in his own time.

In question 10, Participant R suggested a new mechanism he would like to see: "Maybe for each puzzle there can be some ways for you to earn hint instead of offering the help after a few certain tries. Can play a short score to get hints for the 3rd puzzle".

4. Discussion

The investigation described in this paper was approached as an exploratory case study. As argued by [27], there is empirical evidence that the human mind tries to replicate and mimic grounded experiences with concrete outcomes, from knowledge gains to emotions. Author [18] has written about the role of what he has termed Projective Identity in game-based learning. Briefly [21] describes how—in well-designed learning environments—a learner might potentially develop a Projective Identity as an amalgam which complements both his or her atomic (human) identity and the virtual (avatar) identity, and how such Pro-

jective Identities might persist beyond the instantiations of the game and/or the immersive environment to influence values and behaviors in other (non-game) contexts.

Central to author's [21] thesis is an understanding of the role of embodied cognition in learning. Embodied cognition has its origins in the respective work of [28,29]. It can be defined as the involvement of multiple senses for enriching immersion and understanding [30,31]. The term refers to the idea that body and senses are not peripheral components of our thinking, acting instead as structuring parameters operating with respect to one's material environment, situation, and timing [31–33]. This stance of embodied cognition is supported by work in neuroscience. Author [34], for example, has described how emotional impulses are transmitted directly to the amygdala and the insula; these—in turn—lead to actions in the motor system. In sum, mediations at both the individual and social levels involve thought, action and emotion. The three form mutually complementary facets in understanding learning. In this framing, meanings are appropriated through such mediations. Emotion is an integral part of the experience from which subsequent meaning-making is based. Understood thus, intuitions gradually develop into scientific concepts; conversely, scientific concepts are translated to reflexive action. The construct of embodied cognition with respect to mathematics education has been elaborated in [35] and has acquired an increasing popularity because of its relationship with technology such as virtual reality and smart interfaces [30,36]. For example, recent work by [37] has suggested that social interactions in virtual/augmented environments do persist in influencing human behavior even after the actual intervention has ended.

In our study, both participants were able to complete all five puzzles although they found many difficulties in navigating the game. Table 3 demonstrates this explicitly through participant R's response of how the feeling of frustration from the hard puzzles actually fueled him to keep trying. "... the whole game makes me want to keep going after each level. Especially, the third puzzle was frustrating but was very pleasing to play as I develop my strategy. At first it was slow, but eventually I caught on..."

Table 3. Participants' responses to Question 1.

Participants' Response	Content
R1	"... the whole game makes me want to keep going after each level. Especially, 3rd puzzle was frustrating but was very pleasing to play as I develop my strategy. At first it was slow, but eventually I caught on..."
G1	"Yes, spending a lot of time figuring it out makes it (feels) very accomplished . . . At first, I don't know (. . .) didn't want to stop half-way because I feel like I have a goal. Got treasure at the end. Haha."

This is congruent with Gee's [21] belief that a suitably difficult game, no matter if its nature is simple fun, or educational, can place the player in a state that keeps them engaged and continuing to work forward.

Another way that a participant was motivated was through the mentality of achieving the final goal. Participant G's response in Table 3 shows that the source of determination to reach the end of the game was from his initially-established goal—to reach the treasure promised at the beginning of the game. "Yes, spending a lot of time figuring it out makes it (feels) very accomplished . . . At first, I don't know (. . .) didn't want to stop half-way because I feel like I have a goal. Got treasure at the end. Haha".

This shows assigning a non-academic goal for learners in-game can encourage them to engage in the learning process. It affirms the authors' [17] research, which claimed that a goal is effective in keeping a learner move forward in their learning progress. There was improvement in both the participants' music theory knowledge and their attitude toward the subject by allowing them to self-explore within their roles as an expert in music. This can be seen in the change of participant G's attitude, from reluctance and low confidence to

excitement and determination at the end of the game, as inferred from his response cited in the preceding paragraph.

In Tables 2 and 4, responses to Question 4, 5, and 6 from both participants are evidence that they were able not only to understand the musical concepts present but also their possible uses. Without definitions being explicitly given in the game, participants showed no difficulty in observing, exploring and making conclusion regarding their own understanding of musical concepts. This is illustrated in the case of participant G who, despite requiring assistance for Puzzle 5, was still able to give a well-thought-out definition of chords, as: "Multiple notes together (. . .) In a song, chords make it sound more layered".

Table 4. Participants' responses to Question 4.

Participants' Response	Content
R4	"One is slightly lower, one is slightly higher, maybe like half a note? Because the black notes were right in middle (of) two white notes."
G4	"# sounds higher, b sounds lower. On the staircase, the neighboring black keys were on top and bottom."

Comments from participants in response to Question 8 (as presented in Table 5) suggest that the puzzle did not need to be solved in an "intended" way for the learning process to be effective, and it is possible to offer support without taking self-exploration and self-initiative away from learners. The main focus for educational games should not be on how to get learners through a puzzle, but how to ensure they can always explore.

Table 5. Participants' responses to Question 8.

Participants' Response	Content
R8	"The fact that the puzzles are linked, it goes from reading scores, to listening and playing, to scales, to chords. It gets harder but can manage."
G8	"The instructions were helpful."

It can be inferred from the preceding discussion and from Table 6—which compares participants' responses before and after the intervention—that offering a look into how an expert would make use of music theory through these interactive puzzles had helped the learners gained a deeper understanding of the subject, despite being at novice level. This is similar to the results from Shaffer's research on epistemic games previously mentioned, where his participants improved in their both their knowledge and ease at applying this knowledge. However there is limited proof as to how long our participants continue to memorize new knowledge and skills.

Table 6. Participants' responses to Question 0 and Question 9.

Participant	Question 0	Question 9
R	"It's too much knowledge, I feel like I don't even know how to approach it."	"Easier yeah. The reason why I didn't start before is because I don't know where to start. But the game didn't feel overwhelming at all. I might even look more into scales and stuff."
G	"It feels too intuitive, and I'm better with logic."	"Better, definitely. It was easier to understand the concept than I thought."

The game also changed their previous perception of music theory as "unapproachable" into a topic they can make sense of through self-directed learning and application to realistic

contexts in-game. One participant voiced an interest in continuing to explore the subject of music theory outside the context of the game.

It can be concluded that students were able to obtain a good level of basic understanding of musical concepts, and their relationship with the subject has improved, which aligns with results conducted on previous educational escape rooms [38–41].

5. Limitations and Concluding Remarks

This paper has described an independent research project undertaken by a pair of students, with their peers as participants, over the course of nine months in 2022. During this span of time, a bespoke game was conceptualized and enacted, with the narrative of obliging the participant-players to attempt a series of escape room puzzles through which it was hoped they would acquire elements of music theory. As project constraints dictated that the study was carried out among two participants, the investigation was approached qualitatively, and no generalizability is claimed from this exploratory case study.

Participant R's response to Question 7 highlighted an issue with a purely online game. He was unable to familiarize himself with the piano keyboard because the game made use of a virtual one, which made him less sure about his ability when he was told to interact with a physical piano. Since the puzzles only use a computer screen and mouse to navigate the puzzle, the desired effect of an immersive environment is restricted, which even hinder the learners' ability to translate their skills from in-game to real life contexts.

The difference in how Participants R and G responded to the scaffolding mechanism in the game reveal a significant feature that a technology-based educational game is unable to offer: it does not cater to the personal circumstances of each learner, be it one's attitude in learning or existing skills. This is similar to the concern mentioned by Puntambekar & Hubscher [14]. While the game has no trouble in providing specific support and hints when learners increasingly struggle with the puzzles, it is unable to take into account each learner's skill level and mentality. Some learners might find the support irrelevant; some find it not enough. In the case of our participants, R is confident and is able to face the puzzles unassisted, while G is more doubtful of his own ability, which leads to a lot of hesitancy, and he needed more assistance than what the game can provide. The duration of our game was not long enough to implement a gradually fading support system when learners are ready to tackle puzzles on their own without further assistance, but this should be a consideration for future research.

Despite these limitations, we can conclude that puzzle games evidently have positive effects on a learner's motivation and engagement in learning new theories through goal-oriented motivation. The interactive and role-playing nature of the games also encourages learners' self-exploration and development of their own understanding of said theories. The game mechanisms we implemented yielded positive responses and observations from learners, with evident motivation and interest not only in the game itself but also the learning process. An especially promising result is the change in attitude and confidence when approaching a topic they were completely unfamiliar with, despite initially showing apprehension and doubt in their own ability.

We accomplished our goal of introducing participants to elements of basic music theory, namely musical notes, musical notations, scales, and chords, as well as some understanding of their function. While participants also displayed musical skills (reading music sheets and playing by ear), it remains to be seen whether they are able to translate these skills into real life in the long run.

We seek further development in using immersive environments to allow learning to become more dynamic and flexible in the classroom, while still revolving around school-appropriate content. Future research can explore more mediums via which an escape room can be organized for a more effective immersive learning environment, such as using more explicit visual and roleplaying cues or combining the game with a physical MIDI keyboard for learners to interact with. Ultimately, the goal is to further investigate the effect of epistemic games with school-focused content. We should also inquire about other

game mechanism systems that can motivate and engage a learner, such as an achievement system or customized in-game characters.

It can be difficult for educators to find games that focus on specific topics they would like their students to explore. Moreover, while teachers and curriculum designers understand the needs of learners well, they are often unable to replicate educational games involving resource materials in a manner that is interesting or engaging for their students as they lack the skills of professional game designers. We hope that further research into this topic can give them resources to curate their own educational games that are suitable for their classes and subjects.

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