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Sensation in Gamification: A Qualitative Investigation of Background Music in Gamified Learning

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Abstract: Gamification in education has received significant attention for its potential to enhance student engagement and motivation. However, challenges arise from the excessive use of reward-oriented game elements, which are assumed to have negative effects on learning outcomes in many cases. In contrast, while the literature argues immersion-based gamification holds great potential, there is little research on how such an approach affects learning experiences. The Sensation game element, for instance, might contribute to students' experiences by providing sensory queues, such as auditory feedback based on background music, to foster concentration, engagement, and immersive learning experiences. Nevertheless, past studies have not sufficiently investigated how the Sensation game element affects gamified learning experiences. Therefore, this paper implements the Sensation game element in two studies: Study 1 introduced background music during a reading activity, while Study 2 implemented multiple background music tracks aligned with different learning stages to drive students' experiences. Accordingly, we evaluated this game element through usability tests, based on high-fidelity prototypes of online learning environments, followed by semi-structured interviews that were analyzed through thematic analysis with the help of ChatGPT. Overall, we found that Sensation, particularly instrumental music, positively influenced concentration but requires careful design to maintain engagement. The findings highlight the importance of tailoring Sensation's implementation to consider individual preferences and contextual factors and the need for thoughtful selection and management of sensory queues to optimize learning environments effectively. Additionally, we provide evidence emphasizing the value of using tools like ChatGPT to optimize qualitative data analysis, although human oversight remains prominent to ensure robust research outcomes. Overall, this study contributes insights for designing personalized and effective gamified learning experiences based on the Sensation game element in enhancing learning experiences.

Keywords: Gamification, Education, Sensation, Music, ChatGPT.

1 Introduction

Gamification is the use of game elements in non-gaming contexts [Deterding *et al*., 2011]. This approach has been applied in numerous domains, such as personal productivity, marketing, health, and especially education and teaching [Koivisto and Hamari, 2019]. In the educational field, gamification has been widely adopted due to its potential to improve student motivation and engagement, making the learning process more enjoyable and, in turn, more effective [Sailer and Homner, 2020; Huang *et al*., 2020].

Despite the great interest, gamification applied to education can sometimes lead to negative results [Toda *et al*., 2018]. These negative results often happen due to the excessive or inappropriate use/selection of game elements, which can lead to unwanted outcomes, such as loss of attention from learning, and leading to a decrease in the interest of some students over time [Bai *et al*., 2020]. For instance, it is commonplace to attribute such adverse effects to the most used game elements, such as medals, scores, rankings, and points, which are reward-oriented elements [Loughrey and Broin, 2018]. On the other hand, there are several game elements that can be used to gamify learning environments, such as immersion-oriented ones, and should be explored to advance the understanding of how they contributed to learning experiences [Toda *et al*., 2019; Landers *et al*., 2018].

Sensation, for example, is a fictional game element that could drive gamification designs towards immersion and engagement rather than reward-oriented experiences [Huang *et al*., 2020]. According to the Taxonomy of Game Elements in Education Environments (TGEEE), sensation can be defined as the use of visual or sound stimulation to improve learners' experiences [Toda *et al*., 2019]. Through sensory queues, it is possible to enable an immersion that can lead to

positive learning experiences Petersen *et al*. [2022]. Moreover, immersion can enhances the overall student experience by creating an environment that is dynamic, interactive, and conducive to exploration and discovery. Through immersive learning experiences, students are not passive recipients of information but active participants in their educational journey. For example, sound stimulation, in the context of games, is available as audio feedback for some action, such as hitting an enemy, and background music, aiming to create an atmosphere aligned to the current situation (e.g., raising tension during a boss fight) Lipscomb and Zehnder [2004]. Furthermore, background music might help establish an immersive environment, facilitating students' concentration, providing positive emotions, and increasing motivation and interest in the content [Hallam and Himonides, 2022; Kämpfe *et al*., 2011].

Still, there is little evidence on how sensory elements tied to gamified environments can impact on students experiences since most of research on gamification tends to focus on elements of traditional games [Bai *et al*., 2020], leaving gaps in knowledge about the use of game elements such as sensation. In addition, current gamification research also does not consider the students' experience aligned with gamified practices in the learning environment Toledo Palomino *et al*. [2023]. Therefore, this paper expands past research aimed to understand students' experiences when interacting with a gamified educational environment based on the sensation game element, implemented as music de Freitas *et al*. [2023]. To achieve this objective, we report two qualitative studies, based on usability tests and interviews, in which students performed educational activities while listening to background music and, subsequently, discussed their experiences in a semi-structured interview. Thus, the contribution of this paper is an in-depth examination of how the sensation game element influences students' learning experiences, revealing insights into the potential of background music for gamification applied to education based on empirical evidence in the context of online reading.

2 Background

In games, music plays a crucial role as a powerful tool to enhance the player's experience and guide their emotions Guillen *et al*. [2021]. Whether it's the adrenaline-pumping beats of an action-packed sequence or the haunting melodies of a suspenseful moment, music sets the tone and creates a unique atmosphere Rogers *et al*. [2020]. Music can heighten tension, provide a sense of adventure, or invoke nostalgia, effectively driving players towards desired emotional states and deepening their connection with the game. Thereby, by leveraging the emotive power of music, game designers add a layer of depth and engagement that is essential for a captivating gaming experience [Munday, 2007].

In learning settings, music presents potential benefits and issues. Music might create a more immersive and stimulating environment, enhancing the sense of presence and making the learning experience more engaging Hallam and Himonides [2022]. Additionally, it might help improve concentration and focus by blocking out distracting noises and providing a consistent sound environment, keeping learners engaged in the activity Kämpfe *et al*. [2011]. On the other hand, music might become a distraction, making it difficult to concentrate and understand information Mohan and Thomas [2020]. Individual preferences are also a consideration as musical tastes might vary among people. Sensory overload is another concern, as music might overwhelm learners' senses, especially if there are many visual and auditory stimuli happening simultaneously Lehmann and Seufert [2017]. Therefore, whereas music might enhance learning experiences, it should be carefully designed to prevent unwanted outcomes [de la Mora Velasco and Hirumi, 2020].

Based on that context, the remainder of this section backgrounds music's potential for gamification applied to education based on two theoretical foundations, the Sensation game element and Juiceness, and discusses related work.

2.1 The Sensation Game Element

In gamification applied to education, music fits within the sensation game element. The **Sensation** game element plays a critical role in gamification, particularly in educational contexts, by engaging students' sensory experiences to enhance learning and retention. According to Toda *et al*. (2019), the Sensation element involves using visual and auditory stimuli to create immersive and memorable learning experiences Toda *et al*. [2019]. This approach aligns with the broader objectives of gamification, which aims to make educational processes more engaging and effective by incorporating game-like elements.

Applying background music as part of the Sensation element can significantly augment the learning experience. Music and sound effects can be strategically used to create a specific atmosphere or to signal feedback, reinforcing learning through auditory cues Petersen *et al*. [2022]. For example, background music can increase concentration during tasks or provide a positive auditory reward for correct answers, enhancing the sense of achievement and motivation Toda *et al*. [2019]; de la Mora Velasco and Hirumi [2020]. Furthermore, the use of music and sound aligns with the multimodal learning theory, which posits that learners absorb information more effectively when it is presented through multiple channels (visual, auditory, and kinesthetic) Giannakos and Cukurova [2023]. By engaging both visual and auditory senses, gamification can cater to diverse learning preferences and needs, potentially increasing the effectiveness of educational interventions.

In summary, incorporating the Sensation element with a focus on auditory experiences such as background music might enrich the learning environment and support cognitive functions like memory and attention. Therefore, leveraging this element within gamified educational platforms can lead to deeper engagement, better information retention, and a more enjoyable learning process for students.

2.2 Juiceness

Juiciness in game design refers to integrating comprehensive audiovisual feedback that dynamically reacts to player interactions. This design principle enhances user experience by

making game elements appear more animated and responsive. It typically involves multiple feedback layers, such as visual effects, sounds, and vibrations, activated by player actions. These elements are designed to provide immediate and gratifying feedback, enhancing engagement and making the gameplay more rewarding Hicks *et al*. [2019]. In educational gamification, juiciness can significantly enhance student engagement and motivation. Incorporating juicy design elements into educational materials can transform the learning environment into one that mirrors the dynamic and interactive nature of effectively designed games. For example, providing instant and visually appealing feedback, such as colorful animations or satisfying sounds, when students complete tasks or reach educational milestones makes the learning process enjoyable and reinforces the learning by making achievements feel more substantial Durmanova [2022].

Furthermore, juiciness can effectively meet various psychological needs critical for intrinsic motivation, according to Self-Determination Theory (SDT), which is the desired kind of motivation for learning experiences Vansteenkiste *et al*. [2009] given its positive relationship with learning gains Rodrigues *et al*. [2021]; Hanus and Fox [2015]. Particularly, the SDT defines these needs in terms competence, autonomy, and relatedness Ryan and Deci [2017]. Juicy design enhances the sense of competence by providing positive feedback that affirms learners' skills and achievements. It supports autonomy by offering interactive choices in learning materials, which respond uniquely based on user input. Additionally, it fosters a sense of relatedness among students by incorporating elements that promote interaction or competition, such as leaderboards or collaborative goals, enhanced through engaging feedback mechanisms Hicks *et al*. [2019].

Based on that context, an essential component of juiciness in educational settings is background music. This element can significantly amplify the juicy effect by providing auditory feedback that complements visual stimuli, thereby enriching the sensory experience of the learning environment. Background music enhances the aesthetic appeal and supports cognitive functions, helping to maintain concentration and elevate mood, which can be particularly effective in educational activities where motivation might otherwise wane Durmanova [2022].

In summary, by weaving juiciness, including musical elements, into gamification strategies, educators can foster more immersive and motivating learning experiences. This approach is expected to sustain engagement and enhance educational outcomes through improved participation and retention of information. Thus, the strategic use of juicy design in gamification can be crucial in transforming educational environments, making them more interactive, enjoyable, and effective.

2.3 Related Work

Despite the demonstrated prominent role of music in games, the literature still presents little evidence on the effects of music in gamification, which would be implemented as the sensation game element from [Toda *et al*., 2019]. For instance, recent research on gamified learning has explored avatars [Lopes *et al*., 2024] and other game-like [de Sousa Santos *et al*., 2023] perspectives rather than the idea of adding music-based elements into a learning environment. Of the few studies on this topic thus far, we can highlight the work of Altmeyer *et al*. [2022].

Altmeyer *et al*. [2022] investigated the impact of sound effects (as a means to provide feedback) on users' performance and users' experience in a gamified image classification task. However, results showed no significant difference in performance, affect, immersion, or enjoyment among the 317 participants involved in their study. Still, Altmeyer *et al*. [2022] recommends that the use of sound effects in gamification should be a more informed choice and, consequently, would require more attention within gamification research. Notably, while this study provided a valuable contribution, it was limited to sound effects, rather than investigating background music as it this paper.

In light of that gap, we started exploring background music's role in past research de Freitas *et al*. [2023]. However, this study explored a single background music with the goal of driving students' experiences as games do. While de Freitas *et al*. [2023] revealed interesting insights concerning the Sensation game element's usage in gamified learning, games usually feature different background musics that guides players' experiences throughout its varied sections. With this approach, the background music set might be able to drive how one's experience is expected to unfold as they interact with the online learning environment. Accordingly, it provides a way to explore the Sensation game element to implement the system's storytelling and, hence, further improve the immersive experience provided by the gamification design [Toda *et al*., 2019]. Based on that premise, this paper expands the literature by advancing the understanding of students' experiences when interacting with a gamified educational environment based on an elaborated implementation of the Sensation, which is more closely aligned to its functioning in games Petersen *et al*. [2022]; Lipscomb and Zehnder [2004].

To summarize, as there is little evidence on the effects of music in gamified learning, more studies are needed to understand the benefits of sound stimulation in gamification and education. Therefore, this paper contributes to the literature by providing a new understanding on how background music, as a sensation game element, is able to affect learning experiences. For this, this paper presents two empirical studies - Study 1 de Freitas *et al*. [2023] and Study 2, which are detailed in Section 3 and have their results introduced in Section 4.

3 Method

This article presents two studies with the overall goal of understanding how students perceive sensation-based gamification in the context of online learning environments. While the studies differ in terms of gamification implementation, participants, and data analysis, they share a number of similarities. Therefore, this section first presents the elements in which both studies are similar, followed by Sections 3.1 and 3.2, which detail the particulars of studies 1 and 2, respectively. Note that, according to CONEP's Resolution 510 dated April 7th, 2016, it was determined that the studies re-

ported in this article should not be submitted for review by an ethics board. This decision was based on the study's focus on users' opinions regarding a learning environment without the possibility of participant identification.

To achieve this article's overall objective, we conducted usability tests, which have been used to grasp a deep understanding of one's experiences with a given product/design (e.g., studying in an educational environment gamified with music) and, accordingly, have been adopted as a means to conduct qualitative studies [Barbosa *et al*., 2021]. Hence, we considered a suitable approach to reach our primary goal.

To enable our study, we created a high-fidelity prototype aiming to simulate an online learning environment. Specifically, the prototype is a web application based on a four-section sequence. The first section served as an introduction, providing context and instructions regarding this study. The second section contained an expository text (see Table 1 for a snippet of the text), which was accompanied by a music (see details below), to replicate the reading from an online course. The third section consisted of a short quiz with five multiple-choice questions, which were presented individually (each one had its specific page) and aimed to simulate an assignment that follows the reading. Table 2 presents a sample question of the quiz. Finally, the fourth section served as a thank you page, displaying the number of questions that the participant answered correctly.

Table 1. Snipped of the text students read during the usability test from Study 1.

Original Text
A nutrição é fundamental para a saúde e o bem-estar humano. Ela envolve a escolha de alimentos que fornecem nutrientes essenciais para o corpo humano, incluindo vitaminas, minerais, proteínas, carboidratos e gorduras. Quando uma dieta equilibrada é seguida, ela pode melhorar a qualidade de vida, prevenir doenças e manter um peso corporal saudável. Uma alimentação saudável é importante desde a infância, quando o corpo está em desenvolvimento. Uma dieta adequada pode ajudar a garantir que as crianças cresçam e se desenvolvam normalmente. Isso inclui o desenvolvimento do cérebro, ossos, músculos e sistema imunológico.
English Translation
Nutrition is fundamental to human health and well-being. It involves choosing foods that provide essential nutrients for the human body, including vitamins, minerals, proteins, carbohydrates and fats. When a balanced diet is followed, it can improve quality of life, prevent disease and maintain a healthy body weight. A healthy diet is important from childhood, when the body is developing. A proper diet can help ensure that children grow and develop normally. This includes brain, bone, muscle and immune system development.

Within our prototype, we selected *basic nutrition* as the learning subject, which was selected by convenience [Wohlin *et al*., 2012]. Given that our focus was on understanding learners' experiences from the gamification perspective, we chose a general-purpose subject that could potentially benefit our participants and, given their profiles (see below), was unlikely to be discussed in their daily lives. In that context, one researcher developed the reading as well as the five questions. Then, a nutritionist provided feedback on those materials, which were revised accordingly by the researcher who initially developed them. Particularly, we aimed for the reading to have around 1000 words so it would take around five to seven minutes to read it, considering the average time for reading from a screen is 151 words per minute [Dyson and Haselgrove, 2001]. Similarly, we limited the prototype to five questions to prevent maturation effects from a long study [Wohlin *et al*., 2012].

Table 2. Sample question the students were asked to answer during the usability test Study 1.

Original Question
Quais são os nutrientes essenciai para o corpo humano? a) os nutrientes essenciais incluem vitaminas, minerais, proteínas, carboidratos e gorduras; b) apenas proteínas e carboídratos são nutrientes essenciais; c) vitaminas e minerais são os únicos nutrientes essenciais; d) gorduras e proteínas são os nutrientes mais importantes.
English Translation
What are the essential nutrients for the human body? a) essential nutrients include vitamins, minerals, proteins, carbohydrates and fats; b) only proteins and carbohydrates are essential nutrients; c) vitamins and minerals are the only essential nutrients; d) fats and proteins are the most important nutrients.

Building upon our prototype, the usability test procedure was as follows. Each test was carried out face-to-face and individually. Before starting the test, participants provided consent to participate in the study and agreed that the audio would be recorded. The first step was the explanation of the research. Then, the participant would start reading the instructions in the prototype's first section. If the participant had no questions regarding the study, they would move on to the prototype's second section. Once the participant reached the end of the reading, the interviewer asked some questions regarding their learning experience (see details below). Next, the participant proceeded to the prototype's third and fourth sections. Finally, the interviewer continues with additional questions regarding the experience in answering the quiz.

3.1 Study 1

The purpose of this study [de Freitas *et al*., 2023] was to understand the experience of students when interacting with a gamified educational environment based on the Sensation game element.

Particularly, we explored the Sensation game element [Toda *et al*., 2019] to drive learners' mood, similar to music usage in games (see Section 2), by creating a calming, immersive experience that favored concentration. The rationale is that mood and concentration are related to learning [Husain *et al*., 2002; Buil *et al*., 2019; Goldstein, 2014]. For this, we gamified the learning environment with the following song: Coyote Beatz Best Seller of Djonga. This music, with its calm and linear rhythm complemented by distinctive beats, might serve as an audio backdrop that sets the mood and enhances the immersive nature of the gamified environment

[Hallam and Himonides, 2022]. This music acts as a subtle music that accompanies the reader on their textual journey, which might facilitate immersion, concentration, and absorption of the ideas present in the content [Ferreri and Verga, 2016]. Thus, the choice of such a song is justified by the creation of a relaxing and inviting environment that drives learners' moods and creates a calming, immersive reading environment. It is important to note that the selected music is royalty-free, which ensures that there are no legal implications or limitations when using such music.

In this study, each test was carried out in a quiet room, in the presence of only one interviewee and one interviewer, following the previously described procedure. During each test, the prompts summarized in Table 3 were asked for the participant. Prompts 1 (P1) to P5 were asked after the participant finished the reading. P6, P7, and P8 were asked following the quiz section. Note that those are open-ended questions aimed to reveal subjective insights regarding the participants' experiences, according to the exploratory nature of our study's goal [Barbosa *et al*., 2021]. Importantly, the interviewer would ask follow-up questions (e.g., *why do you think so?*, *tell me more about it*, *anything else?*) to extract further insights as recommended by the literature [Blandford *et al*., 2016].

Table 3. Script used in Study 1 to understand students' experiences from using the learning environment gamified with music.

ID	Prompt
P1	What did you think of reading using the prototype?
P2	What did you think of the songs played during your reading?
P3	What did you think of reading the text with songs playing in the background?
P4	Is there anything else about the prototype that you'd like to comment on?
P5	Would you like to make any suggestions?
P6	What did you think of completing the questions in the prototype?
P7	Is there anything else about the prototype that you'd like to comment on?
P8	Would you like to make any suggestions?

Based on that setting, a total of nine interviews were carried out. The participants were students of the Software Engineering undergraduate course at a private university in Brazil's southern region. Of those, eight were men and one was a woman. The students were chosen through non-probabilistic convenience sampling [Wohlin *et al*., 2012], as the participants were students enrolled in classes where one researcher was the lecturer.

The data analysis was based on the following steps. First, one researcher transcribed the recordings from all interviews, which were then anonymized to protect the participants' identities. Second, another researcher used ChatGPT[1] to aid in conducting a thematic analysis of the interviews' transcripts, similar to recent research [Zambrano *et al*., 2023; Blandford *et al*., 2016]. Specifically, the prompt was *I need you to run a Thematic Analysis on the transcripts of the interviews I conducted. The objective of the analysis is to understand students' learning experiences when reading while listening to music. In the transcripts, the person who conducted the interviews is identified as the Interviewer. Participants are identified as P1, P2, P3, P4, P5, P6, P7, P8 and P9. Here is the transcript:*. Following the prompt, the researcher pasted the nine interviews.

Next, the researcher used the following prompt to find the final themes: *Considering the transcripts of interviews conducted by the interviewer with participants P1, P2, P3, P4, P5, P6, P7, P8, and P9, perform a thematic analysis to obtain a more comprehensive view of the students' learning experience regarding reading while listening to music. In addition to themes, your answer should explain what the theme means and cite insights that support the theme. The answer should also identify which participants talked about the theme.* Finally, the same researcher reviewed the themes and their codes, contrasting the results to the interviews' transcriptions to ensure the results' validity. Accordingly, we use quotes when presenting our results in Section 4.

3.2 Study 2

This study builds upon the findings from Study 1 [de Freitas *et al*., 2023]. Its main goal is to further understand the potential of the Sensation game element, which Study 2 implements aiming to drive students' experiences with varying background musics as they interact with the online learning system. Hence, Study 2 differs from Study 1 in terms of the gamification design, besides presenting a new usability test.

For the gamification based on Sensation and Storytelling, we defined a set of background musics that were expected to drive students' experiences as they interacted with our high-fidelity prototype of an online learning environment. Recall that it has four main sections: an introduction, a reading, a quiz, and a thank you page. Therefore, we carefully selected background music to enhance the user experience at each stage. For the introductory section, we chose the chill-out genre, specifically "When we're together" by Alexander Tarasov, aiming to create a relaxed and calm atmosphere for learners as they familiarize themselves with the project Garro *et al*. [2019]. For the reading section, we opted for Lo-fi Hip Hop, represented by "Blue Wednesday" by The Descent. This genre is expected to promote concentration and focus, which is valuable for students engaging with the text material and preparing for the upcoming quiz Hallam and Himonides [2022]; Buil *et al*. [2019]. For the quiz section, we incorporated game music with a combat / suspense theme, specifically "Dance with the Great Vortex - Osial/Liyue Defense Theme" from "Genshin Impact" by Yu-Peng Chen (HOYO-MiX). Inspired by games, the intense and suspenseful tones seek to heighten learners' attention and evaluate their response to deeper-toned background music during challenging moments. Lastly, for the thank you sections, which displays quiz results, we utilized celebratory game music, particularly "Party" from "Harvest Moon: Back to Nature". This choice aims to trigger dopamine release in users, making the experience more enjoyable and potentially encouraging them to submit feedback Rodrigues [2015]. Overall, our music selections were strategically aligned with each stage's objec-

[1] Both studies reported in this paper used ChatGPT's free version (GPT-3.5 Turbo) for data analysis.

tives, aiming to provide more engaging and immersive learning experience as students process throughout the prototype's sections Ferreri and Verga [2016].

In this study, all test were similarly performed face-to-face. However, they differed from those of Study 1 as we could not ensure a quiet room in the presence of only the interviewee and the interviewer (see Section 5.2 for a discussion on this limitation). Additionally, the overall structure of the prompts asked to participants is that summarized in Table 3. Nevertheless, as this study builds upon Study 1, the interviewer deepened the discussion informed by insights found previously as well as directed the prompts to understand the role of having multiple background musics instead of a single one.

Based on that setting, we conducted a total of eight interviews. The participants were seven students and one lecturer of the Software Engineering undergraduate course at a private university in Brazil's southern region. All of them identified as males. Similar to Study 1, those were selected through non-probabilistic convenience sampling [Wohlin *et al*., 2012].

Similar to Study 1, this study relied on ChatGPT to aid in conducting a thematic analysis of its interviews' transcripts. However, this procedure differed in the following aspects, following the discussions from WIPlay 2023 as well as those from the recent literature [Owoahene Acheampong and Nyaaba, 2024].

First, we adopted a new prompt. Recent studies have discussed how well-structured prompts hold the potential to increase the quality of LLMs' outputs White *et al*., 2023. For instance, studies have discussed that assigning a role to the LLM, including clear instructions regarding the task to be done, establishing a context, defining the expected output, and fostering a step-by-step reasoning, among other elements, contribute to achieving more efficient outputs [Giray, 2023; Kojima *et al*., 2022; Gao *et al*., 2023]. Hence, we similarly adopted this approach, aiming to improve our LLM-aieded thematic analysis, which led to the following prompt[2]:

- **Context:** Thematic analysis is a systematic method of breaking down and organizing rich qualitative research data, tagging individual observations and quotes with appropriate codes, to facilitate the discovery of significant themes. A thematic analysis involves finding themes. A theme is a description of a belief, practice, need, or other phenomenon discovered from the data. A theme emerges when related findings appear multiple times across participants or data sources. A thematic analysis can be done in many different ways. One way is the Affinity Diagram, where data is highlighted, cut physically or digitally and reassembled into meaningful groups until themes emerge in a physical or digital picture. All thematic analysis methods assume some amount of coding. Coding refers to the process of labeling text segments with appropriate codes. A code describes the subject of the text and is an abbreviated form of more complicated information. Often, qualitative researchers will not only have a name for each code, but also a description of what the code means and examples of text that do or do not fit the code. Codes allow us to easily classify information and analyze data to discover similarities, differences, and relationships between segments. Codes can be descriptive (they describe what the data is about) and interpretative (they are an analytical reading of the data, adding the researcher's interpretative lens). We can then come to understand the essential themes[3].
- **Role:** Act as a researcher with experience in qualitative research and thematic analysis.
- **Task:** Carry out a thematic analysis based on the INTERVIEWS in order to reveal how students perceive gamification based on a set of background music when using an online teaching platform. After finding the themes and subthemes, you must group and present the INTERVIEW sentences that belong to each subtheme.
- **Criterion:** The themes must be based on INTERVIEW ANSWERS. QUESTIONS only serve to contextualize the ANSWERS.
- **Interviews:** *<interviews transcripts>*

Overall, we use the *context* section to inform the LLM on our understanding of the thematic analysis process as well as its elements. Then, we use the *task* section to explicitly tell the LLM what we expect it to do and how we expect it to respond us. Lastly, the *interviews* section provides the LLM not only with participants answers, but with the question asked. For this, each interview was structured as follows: question 1, answer 1, question 2, answer 2, and so on.

Second, the thematic analysis was conducted in a single step. In contrast to Study 1, which relied on two independent prompts, we designed a single prompt that guided the LLM on achieving our goal at once. Accordingly, the LLM was able to perform the thematic analysis considering the order in which questions were asked as well as all data from all interviews.

Third, we had a professor with over five years of experience in qualitative research reviewing the thematic analysis results. Acknowledging that using LLMs for such a task is prone to issues, such as bias and misleading results [Owoahene Acheampong and Nyaaba, 2024], we asked this professor to review the themes, subthemes, and quotations returned by the LLM to ensure the reliability of our thematic analysis' findings. Particularly, the professor was asked to read the interviews transcripts, the results of the thematic analysis, and then to assess the results in terms of coherence (e.g., are the themes coherent with the interviews transcripts? are there themes of subthemes missing?), accuracy (e.g., do the returned quotations exist in the transcripts or are they hallucinations?), bias (e.g., are there any kind of bias in the results), and reliability (e.g., are the results reliable in light of the interviews transcripts?).

4 Results

This sections presents the results from studies 1 and 2.

[2]The original prompt was in Brazilian Portuguese. The one shown in this article was translated to English using Google Translator.

[3]Adapted from: https://www.nngroup.com/articles/thematic-analysis/

4.1 Study 1

From the analysis of the data, we identified four main themes: Influence of music on focus and concentration, Individual preferences towards music while reading, Impact of music on information retention, and Differing opinions on the effect of music on learning. Next, this section elaborates on each of them.

The first theme, the *Influence of music on focus and concentration*, revealed divergent opinions among the participants. While some of them mentioned that music can help them stay focused while reading, others highlighted that it can be distracting and make it difficult to concentrate. For example, P1 commented that *"It didn't bother. Well, as I have attention deficit, it's a little more difficult to pay attention to what I'm reading, but since it's a subject that I think is cool, so we make an extra effort to pay attention"* and P4 told *"Man, some specific tones within the song I think took away a little attention. The knocks made me go back to reread, for example, the sentence, half of the sentence"*. On the other hand, P7 commented that *"a little calm touch, relaxes and that helps to really concentrate"* and P8 agree, saying that *"For me to concentrate I like tranquility, peace, silence."*

The second topic addressed *Individual preferences regarding music during reading*. Participants express different emotions regarding the type of music they prefer to listen to while reading. Some mentioned prefer classical music, while others highlight a preference for instrumental music. In addition, it was observed that some participants avoid songs with vocals, as they believe that they can interfere with their ability to concentrate. For instance, P1 said "I think the instrumental right? It's the quietest, because often what takes your attention is the vocals," P2? mentioned that "Instrumental sound like, a Lo-Fi I think is very good." On the other hand, P3 contented that "I like both, I love Lo-Fi a lot, which is just the beat there and stuff, but I also love when there's a voice too. I don't necessarily need to understand".

The third theme analyzed was the *Impact of music on information retention*. Participants' opinions differed in this regard. While some stated that music can disrupt information retention, others mentioned that it does not negatively affect the ability to remember content read. For example, P9 mentioned they "don't think it's so advantageous to read like that, because I go back a lot to what I'm reading now, normally, if I listen to music" whereas P4 said that "answering [the question], you remember the touch of the song, so at a certain moment there, oops, it's not this one, it's this one. He remembered the touch right at that time at that moment there".

The fourth topic addressed the *Difference of opinions about the effect of music on learning*. Participants had contrasting perspectives regarding the benefits or harms of music while reading. While some participants highlighted that music creates a more pleasant and relaxed environment for reading, others questioned whether students who claim to learn better with music are just looking for an excuse to listen to it. P3 argued that "If I had read it without the music for me it would be more monotonous", while P9, who is a teacher, said that "most of my students say [music helps], I don't know if it's because they're younger, I don't know. They say they can learn more by listening to music."

4.2 Study 2

First, this section presents the results of the independent review of the thematic analysis performed by ChatGPT. Then, it presents this study's results based on the revised results.

4.2.1 GPT-based Thematic Analysis Review

Overall, the professor considered that the thematic analysis' results were reliable: *I believe that, overall, [ChatGPT's analysis] is reliable, it provides us an overview of the analysis*. However, the professor also raised important considerations regarding themes and quotes selections.

Concerning the themes, the professor discussed both themes found as well as those not found. On the one hand, he analyzed the completeness and nomenclature of the ones found by ChatGPT: *I believe that they [the themes] can all be identified in the interview. My only reservation about the themes and subthemes was the nomenclature of theme 3 and subtheme 3.1, which used the words "Volume" and "Volume Change". It was strange to me because I hadn't seen anything very relevant about volume in the interviews. When I looked again, I realized that the word "volume" was mentioned only once in the interviews, and it wasn't even because of the change in volume as the title of the topic says. So I think it ended up forcing this nomenclature a little*. Based on that insight, we adjusted the theme's name to refer to the music instead of volume.

On the other hand, the professor discuss concerns ChatGPT did not considered a theme. He mentioned the following: *I think there was something missing related to improvements in the study. [...] However, I missed a theme linked to the last question of the interview, which could be linked to improvements.* He also suggested a few quotes regarding the proposed theme and complemented that *As they are more "direct" and less elaborate answers, the context for the GTP may not have been clear.* Based on that insight, we added a new theme concerning *study improvements* to improve the results completeness.

Concerning the quotes, the professor argued that some of them were not properly selected. For instance, he mentioned that *In subtheme 1.1, I think both quotes are not appropriate. [...] analyzing the quotes, there is nothing that the participants say that actually mentions a concentration. In subtheme 1.2, it even uses the same quote as subtheme 1.1, and they are opposing themes. [...] The second quote is ok. The third one I think is not appropriate, once again, because it is too interpretative. In themes 2 and 3, I believe that all quotes are appropriate for the proposed themes.* Based on that insight, we reviewed and adjusted the first theme's quotes to properly reflect them.

Concerning possible analysis biases, the professor discussed the theme-generation procedure. Particularly, he mentioned the following: *I thought it [GPT] relied more on the questions asked than the answers. This is something to think about, as it linked theme 1 to question 1, theme 2 to question 2, and only for theme 3 it varied between different questions. In qualitative analysis, we rely on answers, not*

questions. For example, when I code, I don't code parts of the questions, only the answers. [...] So, I think it was biased by the questions that were asked, and he tried to do an analysis to organize based on those questions.. Based on that insight, it seems that ChatGPT adopted a deductive coding approach (i.e., starting from *a priori* assumptions/questions) rather than an inductive approach Blandford *et al*. [2016]. Considering that both of those approach are valid, we took this as a valuable consideration for future studies, but chose not to perform another analysis as the deductive approach still revealed insights that help achieving this study's objectives.

In summary, the LLM-based analysis was revised as reliable. Nevertheless, this procedure raised important considerations that helped us improve the results, such as adjusting themes' nomenclatures, encompassing broader insights, and selecting new quotes. Additionally, it raised a valuable consideration on the goals of the analysis in terms of deductive versus inductive coding.

4.2.2 Results

The revised thematic analysis included found main themes: Music's Impact on Concentration, Preference for Musical Styles and Instruments, Impact of Music Change, Study Improvement Suggestions. Next, this section elaborates on each of these along with its subthemes.

The first theme, *Impact of Music on Concentration*, concerned two subthemes. One is *Music Helps with Concentration*, wherein participants reported varying experiences regarding the influence of music on their concentration. Some expressed that certain types of music positively affected their focus. For instance, P1 remarked that "it [the reading music beat] seems to go along with my heart rate, what makes me breathe, maybe calm down, gives me a lightness, I even could read a little better [...] it seemed like I could concentrate on my reading." Similarly, P5 said: "Man, the little sound while reading the content before answering [the quiz], it helped a lot to concentrate." On the other hand, the second subtheme is *Music Hinders Concentration*, as other participants highlighted instances where music hindered their concentration. P2 mentioned that "that one [music] specifically, with instrumental music only in the background, I can study fine. However, for the question part, when that more upbeat music started, specifically, I found it very difficult to concentrate." P3 added that "[music] makes it a bit difficult for me to concentrate on what I'm reading, it makes it difficult for me to concentrate on my head."

The second theme, *Preference for Musical Styles and Instrumentation*, also concerned two subthemes. One of them, *Preference for Instrumental Music*, is regarding musical preferences, considering participants showed a preference for instrumental music over vocal-heavy tracks. For instance, P3 said they "prefer it to be more instrumental music, without vocals, not to help me concentrate on the text, but to unfocus my surroundings, to unfocus my environment." P6 concurred stated that they "think instrumental is a bit better than vocal because just vocals can end up focusing more on the lyrics of the song than on what you're reading." Conversely, the second subtheme, *Effect of Instrumentation on Concentration*, reveals that the effect of instrumentation on concentration was nuanced. P8 remarked that "Instrumental music helps to think better, right, because there's no voice speaking in the background." Yet, they also noted that "Instrumental music helps with concentration, but the rhythm change brings a distraction from what's going on beyond the music."

The third theme, *Impact of Music Change*, features another two subthemes. In the first, *Rhythm Changes*, participants commented on how sudden changes in rhythm affected their concentration. P4 noted that the change "came out of nowhere, and I got lost because, like, there was this sudden change." Accordingly, P8 elaborated that the change "causes a bit of distraction from what's going on beyond the music, but also brings this aspect of showing that, like, hey, there's a change." Interestingly, the second subtheme, *Adaptation to Rhythm Changes*, informs that, despite the challenges, some participants adapted to rhythm changes. P4 shared that, after the change, they "got used to it and focused, you know? It was just the sudden change." However, P7 pointed out that "When I was answering the questions, when that more lively music came on, it messed with my thoughts."

The fourth theme, *Study Improvement Suggestions*, does not involve subthemes. Overall, it concerns suggestions that participants made on how the study could be improved based on how they perceived some features of the online learning environment. For instance, P1 suggested the study could feature some distracting noises or other musical styles: *I think that maybe in the reading part I would put maybe, just to maybe disturb the reader more, maybe a little faster music* .... In a similar line, P6 complimented the idea of other music themes: *I think more variety of music, like other types, for example, pop, classical, pop, to test with song variations ...".* These suggestions raise possibilities for improving future studies by simulating real-world situations, wherein random noises are likely to distract students, and including musics more aligned to one's interests.

4.3 Summary

Study 1 uncovered varying perspectives of background music on reading. Participants noted music's potential to aid focus but also recognized its distracting aspects. Preferences ranged from instrumental to vocal music, with some finding vocals disruptive. Views diverged on music's impact on information retention and learning, with some finding it advantageous while others remained skeptical. Study 2 further explored music's influence on concentration, highlighting its dual nature as both a concentration aid and hindrance. Participants favored instrumental music for reading and highlighted how changes in rhythm and volume could impact concentration, either positively or negatively, depending on individual experiences. Overall, both studies showcased the complex relationship between music and cognitive tasks, revealing individual differences in preferences and experiences.

5 Discussion

A main finding concerns the impact of music on concentration. The research findings align with the literature's notion

that music can have both positive and negative effects on concentration, depending on individual preferences and the context in which it is used. In educational settings, background music might enhance concentration by providing a consistent sound environment that blocks out distracting noises, as suggested by the literature Kämpfe *et al*. [2011]. However, the study also found instances where music hindered concentration, consistent with concerns raised in the literature about music becoming a distraction Mohan and Thomas [2020]. While this finding aligns with the Sensation game element's goal of creating immersive and engaging learning experiences, it corroborates gamification literature in terms of yielding outcomes that vary depending from one learner to another Van Roy and Zaman [2018]; Rodrigues *et al*. [2020a]. Thereby, this finding highlights the importance of considering individual differences and contextual factors when incorporating the Sensation game element into educational environments.

Another finding concerns learners' preference for musical styles and instrumentation. The research findings reflect the literature's recognition of individual preferences regarding musical styles and instrumentation. Participants expressed a preference for instrumental music over vocal-heavy tracks, which resonates with the idea that instrumental music might be less distracting and more conducive to concentration in educational settings Hallam and Himonides [2022]; Lehmann and Seufert [2017]. This preference resonates with Juiciness principles, as carefully selected music can enhance the overall aesthetic appeal and support cognitive functions, contributing to a more engaging and effective learning environment Hicks *et al*. [2019]; Durmanova [2022]. Similarly, recent research on gamification applied to education has been increasingly concerned with the issue of personalizing learning experiences Rodrigues *et al*. [2020b]; Klock *et al*. [2020]. Hence, the nuanced effect of instrumentation on concentration, along with preference differences, highlights the complexity of individuals' responses to different musical elements, echoing the need for careful design considerations in leveraging music for educational purposes.

We also found results regarding the impact of music changes throughout the learning experience. These findings align with the literature's emphasis on the importance of maintaining a consistent auditory environment to support learning de la Mora Velasco and Hirumi [2020]. Sudden changes in music rhythm were found to affect concentration differently among participants, with some adapting to the changes while others found them distracting. This finding demonstrates that while changing musics hold the potential to driven students' experiences and contribute to more immersive experiences, following the idea of the Juiceness' concept Hicks *et al*. [2019]; Durmanova [2022]. Nevertheless, one needs to carefully consider how to design the continuity and coherence of the background musics composing the gamification design to prevent disruptions to concentration and learning.

Additionally, we achieved insights on how to improve the studies' experiences. Participants provided suggestions for improving the study, such as including distracting noises or different musical styles, to simulate real-world learning environments better. These suggestions demonstrates the need for flexibility and adaptability in designing gamified learning experiences. By incorporating these suggestions, educators can create more immersive, engaging, and effective gamified learning environments that resonate with learners' preferences and optimize their learning experiences.

Furthermore, another important finding concerns using ChatGPT's aid for qualitative data analysis. On the positive side, the independent evaluation of ChatGPT's thematic analysis indicated it generated a reliable overview of the interview transcripts, optimizing the identification and organization of themes and subthemes. However, challenges emerged as it failed to find one particular theme, which might be explained by our prompt. As it asked for information regarding users experiences with the gamification design, it likely explain ChatGPT not finding the theme related to study improvements. Another important consideration is that some quotes selected to support themes were based on a subjective analysis of the tool. While adjustments were made to enhance the results' quality, concerns about reliance, the overall results were considered reliable, expanding prior research applying ChatGPT similarly De Paoli [2023]; LIXANDRU [2024]. Therefore, this insights highlight that such tools are valuable to optimize qualitative data analysis, whereas it makes it clear that human revision is prominent.

5.1 Implications

Our findings hold important implications for research and practice. First, the detailed understanding of the impact of the Sensation game element on learning experiences highlights the importance of considering individual differences and contextual factors when designing gamified learning environments. While this game element might enhance concentration by providing a consistent sound environment, it can also become a distraction for some learners. This highlights the need for personalized approaches that take into account learners' preferences and sensitivities to different musical elements.

Second, the preference for instrumental music over vocal-heavy tracks among learners suggests that careful selection of musical styles and instrumentation can contribute to a more conducive learning environment. This aligns with the broader trend in gamification literature towards personalized and tailored learning experiences Klock *et al*. [2020]; Rodrigues *et al*. [2020b], emphasizing the need to implement game elements in ways that resonate with learners' preferences and optimize their cognitive functions.

Third, the findings related to the impact of music changes throughout the learning experience emphasize the importance of a careful audio design. This is prominent to ensure continuity and coherence in background music while aiming to drive learners' experiences to prevent disruptions to concentration and learning. Thus, while music changes can enhance immersion and engagement, they should be carefully designed to avoid negative effects on concentration and overall learning outcomes.

Lastly, ChatGPT's aid for qualitative data analysis reinforces the potential of artificial intelligence tools to optimize research processes. While ChatGPT's thematic analysis showed reliability in generating an overview of interview

transcripts, human revision remains crucial for ensuring the accuracy and quality of results. This suggests that artificial intelligence tools can complement human expertise in data analysis but should be used judiciously and in conjunction with human oversight for robust and trustworthy research outcomes.

5.2 Limitations and Future Research Recommendations

This study's findings should be interpreted in light of its limitations. One limitation of our studies is the small sample size of participants from a specific region and educational background, which may limit the generalizability of our findings to broader populations. While a small sample size may limit the generalizability of findings to a broader population Wohlin *et al*. [2012], the qualitative nature of our studies focused on understanding participants' experiences and perceptions deeply Barbosa *et al*. [2021]. The rich qualitative data obtained provided valuable insights into how students perceive sensation-based gamification in online learning environments, aligned with the goals of qualitative studies Blandford *et al*. [2016]. Accordingly, the emphasis on depth rather than breadth in our analysis allows for meaningful interpretations and actionable recommendations. Nevertheless, future studies could involve larger participant pools from various educational backgrounds to enhance the robustness of the results.

Furthermore, in Study 2, we faced challenges in ensuring a consistently quiet environment during interviews. This challenge might have introduced some variability in participants' experiences. However, this limitation is mitigated by the structured nature of our usability tests and interview protocols. Each participant went through the same procedure and was interviewed following the semi-structured procedure as planned, ensuring a degree of consistency in data collection. Moreover, the focus on participants' subjective experiences and perceptions allows for variability in environmental conditions to be considered as part of the overall context, rather than a confounding factor. Still, future could explore more controlled testing environments to minimize external influences on participants' perceptions and advance the understanding in such situation.

Additionally, thematic analysis is inherently subjective, being influenced by researchers' interpretations and the tools used. While our reliance on ChatGPT for thematic analysis introduces potential biases, the interpretation and synthesis of themes were conducted by experienced researchers familiar with qualitative methodologies. This tool served as an aid in data organization and initial coding, which was subsequently reviewed and refined by human analysts. This hybrid approach enhances the rigor and trustworthiness of the qualitative analysis, reducing the impact of algorithmic biases. Moreover, we further addressed this limitation in Study 2 with an independent, human-based evaluation of its results in light of Study 1's considerations and WIPLAY 2023's discussion. Nevertheless, incorporating multiple analysts or employing mixed-method approaches could enhance the validity and reliability of qualitative analyses in future studies.

Lastly, our studies focused on immediate perceptions and experiences during the usability tests. Although long-term effects and follow-up assessments were not conducted, our studies provided valuable immediate perceptions and experiences related to sensation-based gamification. While long-term effects are important considerations, our findings contribute to the understanding of short-term impacts and initial user experiences. Accordingly, future research can build upon these initial insights to investigate sustained effects and longitudinal outcomes.

6 Final Remarks

Gamification applied to education shows promise in enhancing student engagement, motivation, and learning outcomes. However, its improper implementation can lead to negative outcomes, often due to an overemphasis on reward-driven elements. This highlights a crucial gap in understanding the impact of immersive game elements like Sensation, which can significantly influence learning experiences through visual and auditory stimuli. Existing research largely overlooks this element, focusing on traditional game elements and neglecting the holistic student experience within gamified learning environments. Thus, there's a pressing need for research that investigates the role of sensory elements in gamification and their effects on student engagement and learning outcomes.

Therefore, this article presents two qualitative studies to explore students' perceptions of the Sensation game element in the context of gamified learning. Using high-fidelity prototypes simulating an online learning environments, Study 1 implements Sensation by playing a background music during a reading activity, whereas Study 2 implements the same game element by playing multiple background musics aimed to align with different stage of the learning experience, such as contextualization, reading and question-answering. Based on usability tests and interviews, we found that Sensation has a dual impact on concentration, with preferences leaning towards instrumental tracks. The studies also suggested nuances in music changes' effects on learning experiences and suggest improvements for gamified environments, emphasizing adaptability and continuity in design. Additionally, we provide insights on how exploring ChatGPT along with specific human revision is valuable to optimize thematic analysis execution.

Overall, our research has implications for both research and practical application in gamified learning environments. First, understanding the nuanced impact of the Sensation game element stresses the necessity of tailored approaches considering individual differences and contextual factors. Second, the preference for instrumental music indicates the importance of carefully selecting musical elements to enhance learning environments effectively. Third, managing music changes is vital to maintain concentration and engagement. Lastly, while ChatGPT aids qualitative analysis, human oversight remains essential for ensuring robust research outcomes. In conclusion, our findings advocate for personalized, well-designed gamified learning experiences to leverage the Sensation game element effectively while respecting individual preferences and optimizing cognitive functions.

Declarations

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Authors' Contributions

JAF: Software, Investigation, Data Curation, Writing - Original Draft; MO: Software, Investigation, Data Curation, Writing - Original Draft; CM: Methodology, Writing - Original Draft; FA: Software, Resources; AMT: Conceptualization, Methodology, Validation, Writing - Original Draft; PTP: Conceptualization, Methodology, Validation, Writing - Original Draft; ACTK: Conceptualization, Methodology, Validation, Writing - Original Draft; GG: Validation, Data Curation, Writing - Review & Editing; APA: Writing - Review & Editing; Supervision, Funding acquisition; LR: Conceptualization, Methodology, Validation, Writing - Original Draft, Supervision. All authors read and approved the final manuscript.

Competing interests

The authors declare they have no competing interests.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. This decision is based on a mutual agreement between the authors and participants, established before data collection began, which explicitly states that the generated data will not be made publicly available. This approach respects the participants' consent, ensuring their privacy and maintaining the integrity of the research process.

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