Storytelling in Gamified Rhythmic Training

Matevž Pesek[a], Zala Pregelj, Klara Žniderščič[b] and Matija Marolt[c]
Faculty of Computer and Information Science, University of Ljubljana, Slovenia

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Abstract: As virtual reality becomes more accessible, new applications, including those focused on music, are becoming more widespread. In addition, gamification and storytelling elements have already shown positive effects on learning. In this study, we observe the effects of storytelling on the user experience and the development of rhythmic skills in the VR game Steady the Drums! Players use the headset's controllers to perform rhythmic patterns and command troops in a medieval setting. Two versions of the game — one with and one without narration — were developed to compare participants' performance. Improvement in rhythmic skills was measured using the Tapping-PROMS test, while user experience was assessed using questionnaires. The results showed that skills improved overall, with the non-narrated version achieving slightly higher success rates. However, the narrated version received better hedonic ratings, suggesting that while narrative elements may somewhat hinder immediate skill growth, they could increase long-term motivation and encourage continued play.

1 INTRODUCTION

Computer games, originally intended for entertainment, have already been in use for educational purposes for decades (Caitlin Cole and Mackenzie, 2024). By providing an engaging and unconventional learning environment, they often provide additional motivation and contribute to better learning outcomes. In exploring methods to increase learner motivation researchers often turn to educational computer games (Laine and Lindberg, 2020). Additionally, with the development of virtual reality (VR) technology, the educational games and applications increasingly take advantage of VR capabilities (Oyelere et al., 2020). In the context of music education, VR can offer unique, interactive learning experiences, such as virtual musical instruments, rhythm training and immersive music theory lessons, making complex concepts more interesting for music students and amateur musicians.

Another approach to enhancing the appeal of the game and maintaining player interest, not only in educational games, was the integration of a narrative framework (Ryan, 2001). While much of the research on the impact of storytelling has focused on children, some studies suggest that adults — particularly younger generations — also value narrative elements in games (Bormann and Greitemeyer, 2015). However, existing studies have primarily examined PC games, leaving the role of storytelling in VR games largely unexplored. As VR offers a more immersive and interactive experience than traditional gaming platforms, the impact of storytelling in this context could be significantly different.

Our study examines the effects of storytelling in a VR game aimed at improving musical skills, with a particular focus on young adult participants. It examines how the inclusion of a narrative affects the user experience and skill outcomes. To investigate this, we extended the VR game *Steady the Drums!* (Pesek et al., 2024), which aims to develop rhythmic skills, with narratives and studied their effects on players.

The paper is structured as follows: Chapter 2 gives an overview of existing studies and solutions related to music-oriented virtual reality applications and storytelling game elements. Chapter 3 presents the original version of the game together with the implemented improvements. Chapter 4 describes the experimental setup, while chapter 5 presents the results. Finally, chapter 6 concludes with an overview of the study and key findings.

[a] https://orcid.org/0000-0001-9101-0471
[b] https://orcid.org/0009-0006-7641-8472
[c] https://orcid.org/0000-0002-0619-8789

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2 LITERATURE REVIEW

Virtual reality (VR) is a computer simulation in which users are immersed in a 3D environment and can interact with digital objects and scenarios (Shen and Shirmohammadi, 2008; Pozzebon, 2002). By integrating visual, auditory and haptic elements, VR creates a strong sense of physical presence that increases engagement and interactivity (Kim et al., 2017). Originally used in specialized fields, VR still plays a crucial role in military training by providing realistic, safe scenarios for soldiers (Soni and Kaur, 2023), in healthcare by enabling tailored therapies for conditions such as anxiety and phobias and supporting rehabilitation after injuries (Freitas et al., 2021; Wang et al., 2023). Today, VR is mainly used in the entertainment industry, e.g. in games, films and theater, but it is also increasingly being used in education as it enables simulations and interactive learning experiences that go beyond traditional methods (Petersen et al., 2022). Medical students, for example, can study anatomy without the need for physical specimens (Madrigal et al., 2016) and language students can immerse themselves in a foreign environment, which helps them to learn the language faster and better (Kaplan-Rakowski and Wojdynski, 2018). Studies show that VR improves learning outcomes by helping students understand complex concepts in controlled environments (Mazhar and Rifaee, 2023). The effectiveness of VR as an educational tool has also been explored in a comprehensive literature review (Hamilton et al., 2020). In addition, educational video games (EVGs) have gained popularity in schools due to their high intrinsic motivation, meaningful learning contexts, immediate feedback and interactive elements (Padilla-Zea et al., 2014).

Several VR and traditional music-related games and applications have proven to be important tools for improving musical skills. VR musical instruments and augmented reality (AR) applications have been shown to offer significant potential for improving musical skills that are often repetitive and demanding (Serafin et al., 2017). In addition, rhythm video games such as *Rhythm Heaven* have been shown to be effective in improving the rhythmic skills and memory of elementary school music students, suggesting that rhythm-based games are valuable complementary tools. For example, *Beat Saber*, a popular VR rhythm game, challenges players to slice blocks to the beat of the music, which promotes fitness, motor skills and reflexes (Nair et al., 2023). Also in *Osu!*, a rhythm game played on a computer, players must click, turn, and move objects to the beat of the music, with varying levels of difficulty encouraging skill development. The game's community-created polygons determine the timing and position of clicks, offering players a gradual improvement of their skills. *Guitar Hero*, another rhythm game, uses a guitar-shaped controller to simulate playing the guitar with color-coded notes and offers multiple difficulty levels that increase in speed and complexity. Many modern VR games, such as *Beat Saber*, use similar techniques to visualize rhythm. The VR app *Teach Me Drums* aims to improve rhythmic understanding in percussion lessons by synchronizing a 3D video of a teacher playing an African *djembe* drum with the user's drumming. While such applications are innovative, their effectiveness could be improved with more interactive feedback and immersive learning features (Moth-Poulsen et al., 2019).

While these rhythm-based games can help develop musical skills, they each have their own limitations. Teach Me Drums focuses on learning, but has no gamified elements and no storyline. While Rhythm Heaven is a gamified way to practice rhythm, it was developed for the Nintendo DS and not VR, so it lacks the immersive elements of virtual reality. The games vary, with some simulating drumming, while others simply require tapping to a certain tempo or rhythm. Osu! and Guitar Hero are also not VR-based, and Guitar Hero, like Beat Saber, is not about fully recreating rhythm patterns—in both cases, the user must react to on-screen cues rather than following a given rhythm pattern. Although Beat Saber is a VR game, its focus is on movement guidance rather than precise rhythm training, as players are not explicitly guided through the rhythm but synchronize their actions with the soundtrack.

In contrast, Steady the Drums! stands out by combining VR immersion with rhythm training, a gamified structure and a narrative approach. By integrating these elements, it offers a more engaging training experience compared to existing commercial and educational rhythm-based games.

Storytelling has become an important component in game development, and research has shown that it promotes emotional connections, deeper immersion in the game and greater engagement in gameplay (Ryan, 2001; Zichermann and Cunningham, 2011). In educational contexts, storytelling is an effective way to present content in an engaging and memorable way. Research has shown that storytelling improves comprehension and knowledge retention while increasing student motivation and engagement (Bruner, 2002). Virtual storytelling as a technology for interactive teaching enhances interaction between users and electronic systems and enables immersive educational experiences with virtual teachers (Danilicheva

et al., 2009). For some players, narratives evoke virtual external motivation, where an emotional attachment to the game characters creates a desire to influence outcomes, leading to deeper engagement (Bopp, 2008). Recent studies comparing storytelling in VR and traditional games have highlighted the advantage of VR in creating a more personal and emotionally engaging narrative through increased immersion (Chen, 2024), and in both educational and entertainment games, well-crafted narratives are highly valued by their users (Griffiths, 2019).

3 *Steady the Drums!*

Steady the Drums! is a VR game that combines immersive gameplay with rhythmic training. Players use the VR controllers as drumsticks to perform rhythmic patterns and receive both visual and haptic feedback on their performance. The game features levels of increasing difficulty, in which successfully executed patterns build up a combo meter and unlock additional options. The background music reflects the medieval theme of the game. Players must synchronize the tempo of their drumming with the music, and the more accurately they drum, the higher the score will be.

The plot of the game revolves around rhythmic patterns that serve as commands for military units defending a medieval city against attacking enemies. As the difficulty level increases with new waves of enemies, players issue commands through various rhythmic patterns. The damage multiplier increases the attack power of soldiers over time, while the combo meter makes it possible to create new soldiers. However, creating new soldiers resets both the combo meter and the damage multiplier, which can be increased through precise and consistent drumming. Additionally, there are cannonball mini-games that provide players with opportunities to engage in additional rhythmic quests and enhance their power to overcome the enemy. Victory is achieved when the player is able to command his army effectively through twenty levels by maintaining rhythmic precision. The game features rhythmic patterns of varying length and tempo. These patterns, which include pauses and simultaneous drum beats on various types of drums, create complex structures that require coordination and provide advanced rhythmic exercises.

To improve the user experience, we implemented a visual tempo indicator to help players maintain the correct drum tempo, we enabled the option to skip narration using a controller button and to save game progress, and included detailed instructions for rhythmic commands and mini-games. Correctly executed rhythmic patterns are also highlighted in yellow to provide clear and immediate feedback, and we have introduced animations to visually enrich the game.

Figure 1: The player's point of view in the game.

3.1 Storytelling Elements

The game is designed to resemble an animated book, complete with text, corresponding illustrations and voice narration. The story describes a battle in the fictional city of Velaris, where the protagonist, the blacksmith's son, bangs on the drums with hammers. His task is to replace the absent military drummer Cassian, who has accompanied the king and the rest of the army to the east, leaving behind only a parchment with the basic troop commands. This parchment serves as a rhythmic command display for the player and can be seen on Figure 1. As players level up, the environment changes and stronger, more powerful characters are introduced. An example of a higher level is shown in Figure 2. The main enemy is a dark wizard, Amaranth, who wants to conquer Velaris and use the abundant magic crystals as a source of his power. Before each milestone level, the player learns of the background story and motivations of Amaranth's three most important allies. Before the final level, a dramatic narrative sets the stage for the ultimate battle against Amaranth. To increase player engagement, the player is frequently reminded of their proximity to victory and that the survival of Velaris depends on their actions.

For research purposes, we developed two versions of the game: one that incorporated storytelling elements with narration and one that did not. The version

with storytelling included the characters' backstories revealed at key milestones, while the other version featured the same characters but had no backstory.

Figure 2: Gameplay view at a higher level.

3.2 Tools and Technologies

The game was developed using the Unity game engine, a widely used platform for creating high-quality 3D and 2D games. We used the C# programming language within Unity, as its support for object-oriented programming was essential for implementing complex game mechanics. For integration with virtual reality (VR) devices, we used OpenXR, which ensures compatibility with a wide range of VR and AR devices and eliminates the need for extensive code customization. To enable a seamless user experience without interruptions or motion sickness, we implemented several techniques to improve real-time game performance.

To evaluate the effects of each version of the game, we implemented tracking logic to record players' actions, which were sent to a server in real time and enabled us to measure their precision when striking the drums. To prevent potential data loss while sending it to a server in real time, we also saved the measurements to local data storage and regularly synchronized it with the server.

4 EXPERIMENTAL SETUP

Our study focused on the implementation of storytelling and evaluation of its effects on the user experience. We concentrated on playability, player performance and the improvement of rhythmic skills. Participants were randomly divided into two groups, with one group playing a version that included storytelling elements and the other playing a version without them. Both groups used VR devices — Meta Quest 2 and 3 — with the versions evenly distributed to minimize device-related bias.

We evaluated the attractiveness and effectiveness of the game based on several criteria. During gameplay, we tracked and analyzed data such as the duration of playing, the performance of rhythmic patterns, and the time spent on narrative elements. To assess the improvement of rhythmic skills, we used a shortened version of the PROMS (Profile of Music Perception Skills) test (Georgi et al., 2023). Each Tapping-PROMS session included three rhythmic patterns and three tempo patterns of varying difficulty, selected from the official patterns on https://osf.io/df2gr/. The sessions were conducted using a Python-based application developed for the Tapping-PROMS study. The results provided data on the number of correctly reproduced rhythm and tempo items, absolute synchronization of rhythm or tempo, and relative synchronization of rhythm. For analysis of both Tapping-PROMS test results, we assumed a normal distribution of the data and used the Levene test to assess the equality of variances. For homogeneous variances ($p \geq 0.05$), we applied paired t-tests (Ross and Willson, 2017) and if the variances were not homogeneous, we used the non-parametric Wilcoxon signed-rank test (Randles, 2006). In addition to Tapping-PROMS tests, we used a short questionnaire to collect data on the participants' previous music and gaming experience and a standardized UEQ questionnaire to evaluate the user experience with the game.

Our experiment was divided into three phases. At the first in-person meeting, participants completed a Tapping-PROMS baseline test and a profiling questionnaire. The questionnaire collected basic demographic information, details about the participants' musical background and their experience with digital and VR games. During this session, participants were also instructed on how to use the device, how to troubleshoot common issues and how to access technical support.

During the 14-day gameplay period, participants were instructed to use the device for at least 10 minutes per day. Tracking logic was implemented to record the total playing time, the start and end level of each session, and the number of rhythmic patterns successfully executed. Each drum beat was recorded to allow for more detailed analysis, such as the proportion of beats from correctly executed rhythmic sequences in relation to the total number of beats. For the narrative version, we also tracked engagement with the story section.

During the second in-person meeting, participants performed the final Tapping-PROMS test and completed the shorter version of the User Experience Questionnaire, known as UEQ-S (Schrepp et al., 2017). The UEQ-S contains eight items that target two meta-dimensions: pragmatic quality and hedonic quality. Participants rated the attributes on a 5-point Likert scale, focusing on whether they found the game as rather obstructive or supportive, complicated or easy, inefficient or efficient, confusing or clear, boring or exciting, uninteresting or interesting, conventional or inventive, and usual or leading-edge. In addition, participants from the group that played the game with narrative elements were asked to rate parts of the game related to storytelling, and all participants could express their general comments and opinions.

5 RESULTS

5.1 Demographics

Of the 30 participants in the study, 18 were women and 12 were men. Their ages ranged from 17 to 26 years, with an average age of 21.6 years.

Two thirds of the participants stated that they had not attended music school, however, 20 participants confirmed that they had participated in music-related activities. Dancing was the most common activity (reported by nine participants), followed by singing and playing in a band. Of these 20 participants, most attended courses or received formal training, while a few were self-taught. In addition, 13 participants reported playing at least one musical instrument, with piano being the most common, followed by guitar, flute and violin.

The majority of participants (31 out of 33) had previous experience with video games, with 10 still actively playing. Their playing time varied from less than 3 hours per month to up to 15 hours per month. Most participants played on gaming consoles such as the Nintendo Switch, PlayStation and Xbox, while others used PCs or smartphones. The most frequently played genres included action, adventure, simulation, strategy and sports games.

In contrast, few participants had experience with VR devices. Seven participants had previously used headsets such as Oculus Quest, Oculus Rift or Steam Index, and two had experience with augmented reality glasses. Of these, one participant stated that they used a VR headset on a daily basis, while the others had only tried them out. Four participants stated that they felt nauseous when using a VR headset.

5.2 Gameplay Tracking

Most participants adhered to the instruction to play for at least 10 minutes per day. The participants in the non-narrative group played slightly longer than the participants in the narrative group, with the non-narrative version being played on average 10 minutes longer. In addition, two participants in the non-narrative group had a significantly longer playing time than the other participants. In order not to distort the average results and to avoid inaccurate interpretation, these outliers were excluded from the analysis. The demographic data and the information on previous gaming experience provided in the profiling questionnaire did not appear to influence the gaming time results.

In the storytelling version of the game, we also tracked how often players chose to watch the narrated parts or skip the story by clicking a designated button. The stories were only shown at the beginning and at each milestone level. On the first playthrough, all participants watched the story in full, but skipped it on subsequent playthroughs. Watching the story takes about 10 minutes in total and therefore did not considerably increase the total playtime.

We compared player performance by analyzing the percentage of successful drum hits and the frequency of reaching game levels. Participants achieved very high success rates in both versions, indicating a strong ability to follow the rhythm, however the average success rate was higher in the version without storytelling elements (72.2%) than in the version with storytelling elements (67.8%) with the standard deviation being the same in both groups (13,7%). The difference in the test results is not particularly significant, but the slightly better performance in the version without storytelling could indicate a lower perceived complexity of the game due to fewer interruptions and cognitive load or a higher level of motivation and concentration among players in this group. The results are shown in Figure 3, where the darker sections of the bars represent successful drum hits and the lighter sections show the total number of hits per participant. The percentage success rate is shown on both sides of the bars.

A similar number of participants completed the final level in both groups — five players in the storytelling version and six players in the non-storytelling version. The highest number of successful playthroughs to the final level occurred when players started with the first level. This trend can be attributed to the cannon feature, which is a great help when fighting enemies and can only be activated when playing the game from the beginning.

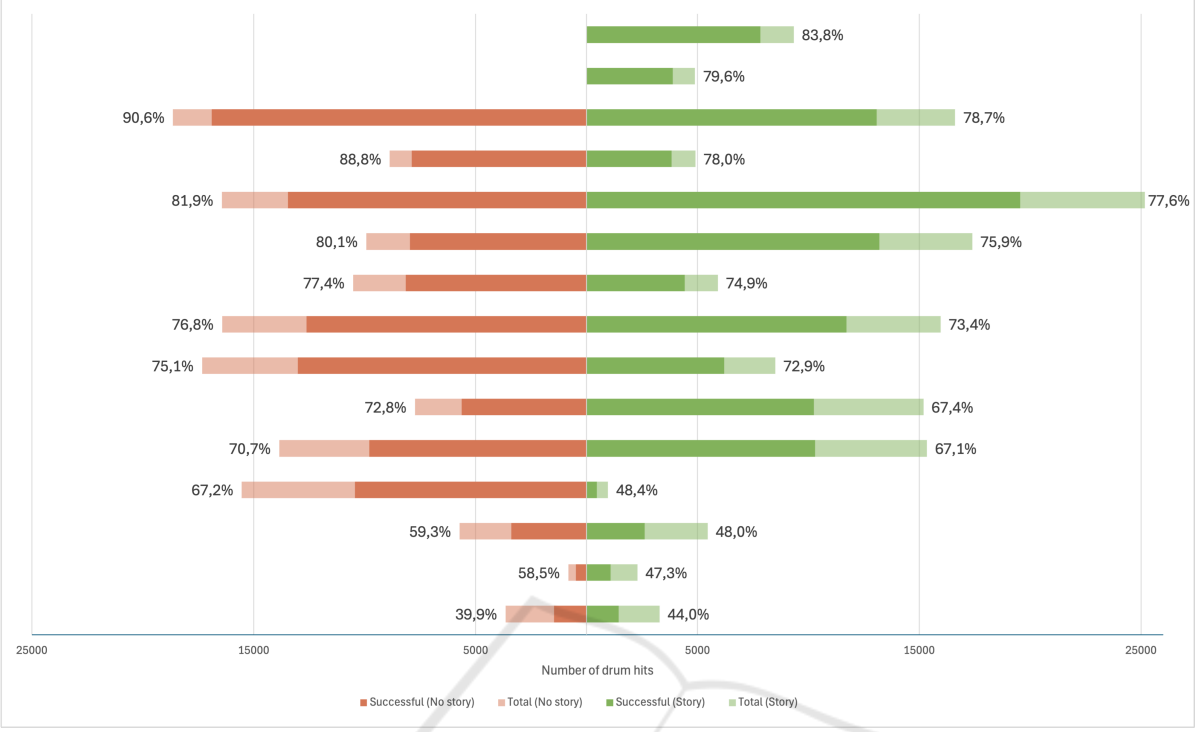

Figure 3: Percentage of successful drum hits per participant.

A comparison with the demographic data revealed that participants who played video games regularly tended to reach higher levels. These participants were also more likely to use the option to start with a saved game state and continue playing from higher levels.

5.3 Rhythmic Test

We observed the improvement in rhythmic skills by examining the changes in rhythmic and tempo synchronization in the Tapping-PROMS test before and after playing the game. Before the comparison, we applied the Levene's test to assess the equality of variances. Based on these results, we applied a paired-samples t-test or Wilcoxon signed-rank test to compare the results of the Tapping-PROMS test and analyze statistically significant differences. Some invalid results from improperly conducted tests were excluded, resulting in a final sample size of 26 participants.

Absolute asynchrony assesses the accuracy of taps relative to ideal time intervals. There was an improvement with easier and moderately difficult rhythmic patterns ($p = 0.012$ and $p = 0.003$, respectively), suggesting that participants became more adept at synchronizing their taps with less complex patterns, although they did not make significant progress with more complicated rhythms.

Relative asynchrony, which measures the consistency of taps within the rhythmic pattern, showed improvements across all difficulty levels, suggesting that participants became better at maintaining alignment with the rhythm, even if they did not maintain perfect tempo synchronization. The greatest progress was observed in the easiest patterns.

We compared the results of the participants from both test groups. Due to the smaller sample size, the distribution is adjusted to 11 participants who played the game version with storytelling elements (marked with S) and 15 participants who played the version without these elements (marked with N). This comparison of absolute asynchrony (Table 1) and relative asynchrony (Table 2) test results allowed us to assess whether the inclusion of narrative elements influenced the degree of improvement in rhythmic synchronization.

The group that played the non-narrative version of the game showed greater progress overall. In terms of absolute asynchrony, they showed the most significant improvements in easier and moderately difficult rhythmic patterns ($p = 0.022$ and $p = 0.014$, respectively). In addition, they improved in relative asynchrony at low and high levels of difficulty, with $p < 0.001$ and $p = 0.026$, respectively.

On the other hand, the group that played the version of the game with narrative elements also showed

Table 1: Analysis of changes in absolute asynchrony results in the rhythmic PROMS test.

Rhythmic Pattern Difficulty		Absolute Asynchrony				T test	W test	p
		Initial Test		Final Test				
		μ	σ	μ	σ			
Low	N	0.338	0.172	0.183	0.128	2.384	/	0.022*
	S	0.505	0.512	0.145	0.093	1.740	/	0.066
Medium	N	1.927	1.183	1.116	0.863	2.489	/	0.014*
	S	1.842	1.323	1.291	0.851	1.941	/	0.048*
High	N	2.796	1.689	2.743	1.069	/	30**	0.452
	S	4.415	0.826	3.695	1.239	1.791	/	0.056

Note: * indicates statistical significance at $p < 0.05$. **Ranks between 1–11.

Table 2: Analysis of relative asynchrony in the rhythmic PROMS test for both groups.

Rhythmic Pattern Difficulty		Relative Asynchrony				T test	p
		Initial Test		Final Test			
		μ	σ	μ	σ		
Low	N	0.203	0.065	0.095	0.033	5.926	< 0.001*
	S	0.345	0.292	0.089	0.041	2.371	0.028*
Medium	N	1.332	0.967	0.794	0.798	1.715	0.056
	S	1.087	1.030	0.976	0.907	0.842	0.216
High	N	1.637	1.190	1.237	1.100	2.198	0.026*
	S	3.043	1.062	2.155	1.456	1.908	0.046*

Note: * indicates statistical significance at $p < 0.05$.

progress, albeit less pronounced. In terms of absolute asynchrony, they showed significant progress with moderately difficult rhythms ($p = 0.048$) and in terms of relative asynchrony, notable improvements were observed at low ($p = 0.028$) and high levels of difficulty ($p = 0.046$).

5.4 User Experience

The results of the user questionnaire showed differences in pragmatic and hedonic quality in the evaluation of the two versions of the game. While the ratings for pragmatic qualities such as supportiveness, easiness, efficiency and clarity were on the positive side in both test groups, they were higher in the group of participants who played the non-narrative version of the game. On the other hand, hedonic qualities scored higher overall in the group that played the version of the game with narrative elements. This means that users found the game with narrative elements more exciting, more interesting, more imaginative and leading-edge.

The participants who played the version with narrative elements confirmed that the story offered enough content, but found it boring to watch the story again after the first playthrough. Their statement was also confirmed by the data we collected during gameplay, as most participants only watched the story once and skipped it on subsequent playthroughs. Although the narrative elements were appreciated, many participants commented that a greater variety of levels would make the game more interesting and less repetitive. The players who experienced the game with narrative elements rated it higher, indicating a greater willingness to pay for the game if it were offered as a paid application.

6 CONCLUSION

In this study, we investigated the effects of integrating storytelling elements into a music-oriented VR game, *Steady the Drums!* Our findings show that integrating new technologies into music training not only modernizes the learning experience, but also provides innovative ways to engage and motivate music students and enthusiasts.

The study combined an improved and upgraded video game design with storytelling elements and allowed players to improve their rhythmic skills by playing rhythm patterns with varying levels of difficulty. The results of the Tapping PROMS test showed an overall improvement in rhythm perception and performance skills of the study participants. However, when we compared the effects of playing with and without narrative elements, we found that the latter produced better performance results. While narrative elements added hedonic qualities that increased

users' enjoyment and motivation, they seemed to detract somewhat from pragmatic qualities, potentially distracting players from the core task of skill acquisition. These results could be attributed to increased cognitive load or interruptions caused by storytelling elements as well as other influencing factors. However, further research would be needed to clarify these assumptions.

These results suggest that storytelling, while not directly optimizing short-term skill progress, may play a critical role in maintaining long-term motivation and engagement, ultimately supporting continuous improvement. However, these conclusions should be interpreted with caution due to the limited sample size of this study.

Future research should examine these effects in a larger and more diverse population, including younger audiences who may benefit more from narrative designs and older adults for whom non-narrative formats may be more effective. Expanding this research will provide deeper insights into the interplay of storytelling, motivation and skill development in music training through VR technology.

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