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College of Computing, Informatics, and Mathematics
Universiti Teknologi MARA Cawangan Melaka, Kampus Jasin
77300, Merlimau, Melaka Bandaraya Bersejarah

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PREFACE

Welcome to the inaugural volume of the **Progress in Computing and Mathematics Journal (PCMJ)**, a publication proudly presented by the College of Computing, Informatics, and Mathematics at UiTM Cawangan Melaka.

This journal represents a significant step in our commitment to fostering a vibrant research culture, initially providing a crucial platform for our undergraduate students to showcase their intellectual curiosity, dedication to scholarly pursuit, and potential to contribute to the broader academic discourse in the fields of computing and mathematics. However, we envision PCMJ evolving into a beacon for researchers both nationally and internationally. We aspire to cultivate a space where groundbreaking research and innovative ideas converge, fostering collaboration and intellectual exchange among established scholars and emerging talents alike.

The manuscripts featured in this first volume, predominantly authored by our undergraduate students, are a testament to the hard work and dedication of these budding researchers, as well as the guidance and support provided by their faculty mentors. They cover a diverse range of topics, reflecting the breadth and depth of research interests within our college, and set the stage for the high-quality scholarship we aim to attract in future volumes.

As editors, we are honored to have played a role in bringing this journal to fruition. We extend our sincere gratitude to all the authors, reviewers, and members of the editorial board for their invaluable contributions. We also acknowledge the unwavering support of the college administration in making this initiative possible.

We hope that PCMJ will inspire future generations of students and researchers to embrace research and innovation, to push the boundaries of knowledge, and to make their mark on the world of computing and mathematics.

Editors
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TURN-BASED ROLE-PLAYING GAME BASED ON MUSIC THEORY

Muhammad Farhan Bin Mohd Jalani
Universiti Teknologi MARA
2022745883@student.uitm.edu.my

Anita Binti Mohd Yasin
Universiti Teknologi MARA
anita008@uitm.edu.my

Dr. Nurul Hidayah Binti Mat Zain
Universiti Teknologi MARA
nurul417@uitm.edu.my

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Abstract

Music theory serves as a universal language, expressing a wide range of human emotions and experiences. This project targets college students who struggle with basic music theory principles and beginners encountering difficulties with fundamental musical skills. Its objective is to create and develop a turn-based role-playing game for learning music theory and to evaluate the effectiveness of a turn-based role-playing game for learning music theory. This project utilizes the Agile methodology. The evaluation results indicate a success rate of 84.0% in achieving project objectives.

Keywords: Music theory; Turn-based, RPG; Game

INTRODUCTION

Music theory serves as a universal language for expressing emotions and experiences across cultures and time periods, demonstrating human interconnectedness through sound. Music education is provided in a variety of settings, including schools and special classes, and includes both structured programmes and informal methods, such as private lessons, to ensure a comprehensive learning experience (Pesek, Vučko, Šavli, Kavčič, & Marolt, 2020). Despite the joy that music brings, students frequently dislike learning music theory and ear training through traditional methods, which can impede their overall musical development. This project

addresses this issue by developing an interactive role-playing game for teaching music theory using game-based learning techniques, with the goal of making learning more engaging and beneficial, particularly for beginners (Asadi, Babu, Shubham, & Shenoy, 2021).

Problem Statement

Students Stumble over Basic Principles

Inexperienced students, particularly those without any prior musical knowledge, often struggle to grasp the complexities of music theory. Before attempting to compose music, fundamental concepts must be understood first, which can be frustrating and demoralising. Many college students stumble over basic principles and seek to learn just enough to earn a passing grade, many tools that will aid their future performances are dismissed because the students do not understand either the concept or the relevance (Miller, 2008). This project aims to solve the issue by providing music theory in a structured and understandable way. Students will be introduced to music theory in a way that captures their interest through an engaging game-based learning approach to ensure a more in-depth understanding.

Difficulty in Acquiring Beginner Musical Skills and Knowledge

As a beginner, learning music theory can be difficult due to several obstacles such as the lack of accessible resources and practical learning opportunities. Consequently, beginners will find themselves overwhelmed by the complexities of music theory. Many adults who start learning music get easily frustrated when the process of acquiring beginner musical skills and knowledge becomes difficult due to the lack of information and the absence of opportunities to practice music at an amateur level (Adamyan, 2018). This project aims to solve the issue by integrating music theory into an interactive game that can offer beginners a practical learning environment.

Objective

The objectives of this project are:

1. To design a turn-based role-playing game for learning music theory.
2. To develop a turn-based role-playing game for learning music theory.
3. To evaluate the effectiveness of playing a turn-based role-playing game for learning music theory.

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Project Scope

This project aims to develop a turn-based role-playing game for beginners with minimal music theory knowledge, compatible with Microsoft Windows and created using the Unity game engine, primarily in English. It seeks to teach fundamental music theory concepts such as notes, accidentals, and scales through interactive gameplay, based on Catherine Schmidt-Jones' book "Understanding Basic Music Theory" from 2007. Players will explore music theory within the game's storyline, interacting with non-player characters to learn concepts. The game will feature monsters representing musical instruments, each vulnerable to specific musical scales. Using a game-based learning model, players and monsters will take turns in battles, with players needing to complete a scale matching the enemy's weakness to gain an advantage in combat.

Project Significant

This project is significant for its engaging and interactive approach to teaching music theory, particularly beneficial for beginners. Its interactive features enhance the learning experience, attracting and retaining learners' attention. Additionally, the project allows players to apply music theory in a virtual world, offering experiential learning opportunities. This is valuable for those who prefer practical learning and want to apply theoretical knowledge to real-world scenarios, strengthening the learning process. Moreover, the project accommodates individual learning paces by tailoring difficulty and lessons to the user's musical knowledge level, making it effective and enjoyable for all players, whether beginners or experienced musicians.

LITERATURE REVIEW

Music

Music, often called the universal language, is the art of arranging sounds to create captivating and emotive experiences. It's made by vibrating objects, with the resulting vibrations detected by our ears. Sounds in music have unique qualities that differentiate them from other sounds. To be classified as music, a sound must meet specific criteria, known as the elements of music. These elements, such as melody, harmony, rhythm, and timbre, form the foundation of this art form (Kwasi, 2023).

The elements of music are essential components that define musical compositions. The first element is beat and metre, providing a rhythmic framework with organised patterns like duple, triple, or quadruple beats. Time signatures represent these patterns. Dynamics, the second element, refers to the varying levels of volume, from soft to loud, in music. Pitch, the third element, determines whether a sound is high or low, perceived through frequency. Melody, the fourth element, is the core tune of a composition, created by arranging notes. Harmony and tonality, the fifth element, blend notes or chords harmoniously, with tonality organising pitch hierarchically around a main key. Notation, the sixth element, uses symbols to represent music, such as the staff notation system. Texture, the seventh element, relates to the interaction of melodic, rhythmic, and harmonic elements. Rhythm, the eighth element, is the movement of musical notes across time, essential in all music. Lastly, timbre, the ninth element, refers to the quality of tone, distinguishing one instrument or voice from another.

This project focuses on pitch and scale (tonality) as the key elements of music. This choice is driven by the fact that this project's main audience is beginners. Starting with understanding individual notes and then moving on to scale concepts will provide a smoother learning curve. This project's goal is to make learning music theory more intuitive, allowing beginners to grasp fundamental concepts gradually.

Video Game

Video games are digital experiences delivered through video formats or electronic displays, classified as computer games in research studies. Players interact with these immersive experiences using screens and input devices like joysticks and keyboards. Modern controllers integrate gyro sensors, motion controls, and directional pads, enhancing immersion. Schell (2008) defines four key elements of video games: mechanics, aesthetics, story, and technology. Mechanics are the interactive rules governing gameplay, while aesthetics include visual and auditory aspects. The story adds depth, and technology encompasses hardware and software supporting the gaming experience. Video games, available on various platforms, serve entertainment and educational purposes. Entertainment games focus on player enjoyment, engaging players with game mechanics, graphics, soundtracks, and storylines. Serious games, used for training and education, leverage the immersive nature of games for learning new skills and knowledge.

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Game Genre

Game genres, or player interaction classifications (Pratama, 2014), are crucial choices for game developers to align with a game's purpose (Aslan, 2015). Genres like adventure, strategy, puzzle, fighting, action, sport, simulation, RPG, and TBS offer diverse experiences. This project focuses on implementing the RPG and TBS genres, delving deeper into their specifics. RPGs immerse players in role-playing, allowing them to customize characters and experience complex narratives, enhancing enjoyment and sense of accomplishment. TBS games, on the other hand, challenge players to strategize and outwit opponents in turn-based combat scenarios, improving cognitive abilities. This project will blend RPG and TBS genres for a rich and immersive experience. RPG elements will integrate music theory into gameplay for deeper immersion, while TBS will challenge players' strategic thinking. This combination aims to offer a comprehensive experience with narrative depth, immersive gameplay, and strategic challenges.

Game Based Learning Design Model

Game-based learning (GBL) uses games with set learning goals to create interactive learning environments. GBL aims to balance educational content with engaging gameplay, making learning more dynamic. Participants actively engage with the material, leading to better understanding. Designing a digital GBL system involves defining clear game goals aligned with educational objectives, developing engaging game mechanisms, encouraging user interaction, providing freedom in the digital environment, creating a captivating game fantasy, incorporating narrative, adding sensation for immersion, emphasizing game value, introducing appropriate challenges, fostering social interactions, and infusing a sense of mystery (Shi, & Shih, 2015). These elements ensure a comprehensive and effective educational experience.

This project will focus on 10 key elements of the GBL design model: game goals, game mechanics, interaction, freedom, game fantasy, narrative, sensation, game value, challenge, and mystery. These elements are chosen to enhance the single-player adventure experience, prioritizing captivating and immersive gameplay. The project is tailored for single-player audiences, so social interactions with other players are not included.

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METHODOLOGY

Agile methodology, known for its iterative and incremental approaches, emphasizes adaptability and active client interaction throughout the software development process (Mohammad, 2023). This approach enables continuous feedback and adjustment, creating a dynamic environment that responds to changing requirements and stakeholder needs. The decision to use Agile in this project was influenced by its core principle of prioritizing close collaboration among developers, testers, and clients (Beck, 2001), aiming to utilize combined expertise for project success. Agile's iterative and adaptive nature makes it ideal for evolving or frequently changing requirements (Highsmith, 2000), allowing development teams to respond with agility and effectiveness.

Agile Methodology Phases

Agile methodology divides the development process into distinct phases. The first phase is planning, which includes defining the project scope, identifying stakeholders, and prioritising features. Following that, the design phase begins, which involves creating a high-level design and laying the architectural foundation for the system. The third phase is development, which involves implementing features from the prioritised backlog. Following this, the testing phase begins, with a focus on ensuring the quality and functionality of the developed features. The fifth phase is deployment, which marks the product's release to end users. The final phase consists of evaluating the completed iteration and gathering feedback for future improvements. Figure 1 shows all phases in the agile methodology.

Figure 1: Phases in Agile Methodology

Planning Phase

The project started by researching music theory problems to gather requirements. After exploring various techniques, a game-based learning model was chosen. The scope was set by planning hardware, and software needs, crucial for defining project boundaries and parameters. Hardware requirements are the essential physical components needed for a system, application, or device to ensure compatibility and optimal performance.

The software requirements for this project list the tools used for design and development, including the Unity game engine for game development and Krita for sprite drawing. Unity, a versatile game engine supporting various platforms, was chosen for its 2D game creation capabilities and robust graphics features like sprites and animations. Its use of C# for scripting eased development. Krita, an open-source raster graphics editor, was selected for its suitability for digital art and 2D animation, offering advanced features like layer management and customisable brushes.

Design Phase

The project began with research into music theory challenges, which shaped its objectives. A comprehensive flowchart and storyboard were created to map out the game's progress and visualize its design. Gameplay mechanics were designed and tested, and the narrative developed through simple doodles. Graphics were created in Krita, with some sprites sourced from asset libraries. The game world was carefully designed, with NPCs and monsters strategically placed. Core gameplay mechanics were implemented and tested, including an interaction system for adaptability. The final stage involved compiling the game into an executable file, distributing it to testers for evaluation and feedback.

The flowchart begins with players navigating the main menu, offering options to start a new game, continue a saved game, access tutorials, adjust settings, view credits, or exit. Starting a new game prompts players to enter their character's name. Once in the game, players can explore the world and interact with NPCs, some of whom offer quests with rewards upon completion. Encountering a monster initiates a fight, and completing all quests in the world signifies winning the game. Figure 2 illustrates the flow of the game.

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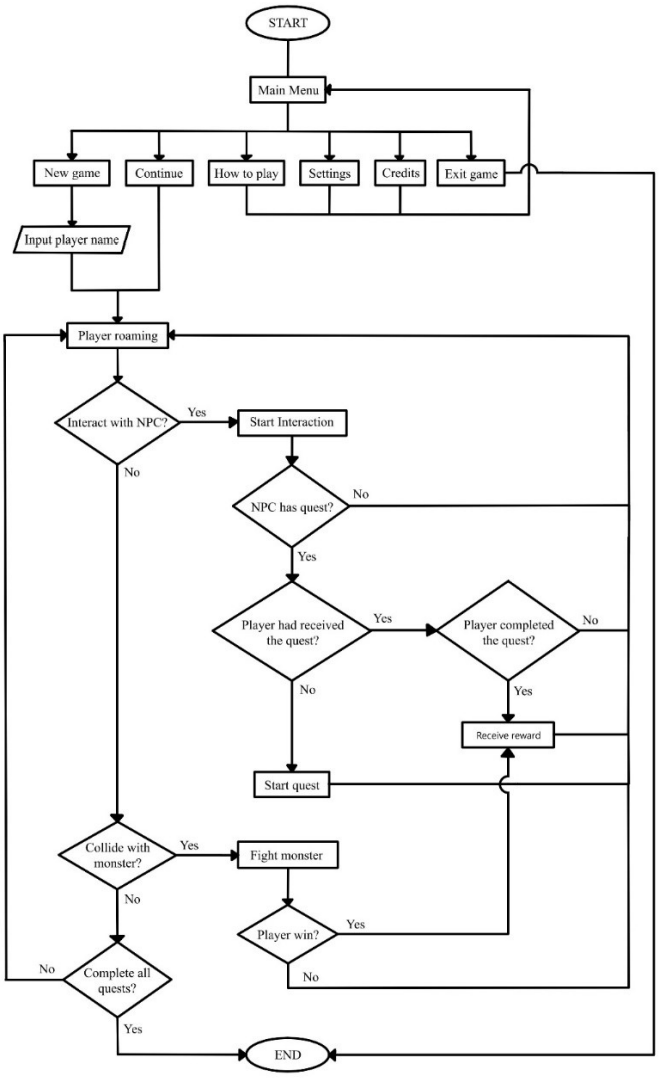

Figure 2: Flowchart of Instrumental Monster

Development Phase

The development phase started with implementing core gameplay mechanics, forming the foundation for interactive elements. The game world was designed to align with project objectives and theme, and UI elements were created to offer player guidance. Sound effects were incorporated to enhance feedback and immersion.

The game includes a variety of characters, such as the player, NPCs, and monsters, each meticulously designed using Krita. Player sprites were created from four perspectives with animations for idle and walking states. NPCs were designed with tools used in music lessons, while monsters were inspired by musical instruments like the piano, guitar, and drum.

The project mostly imported environmental assets, including tile maps and objects created by Butter Milk, strategically placed to align with game-based learning (GBL) design elements emphasizing mystery. Several towns were designed to diversify the game world and enhance player engagement.

In the early stages of gameplay development, the player controller was a key focus, using a finite state machine to manage player states like roaming, interacting, and fighting. This approach offered structured and dynamic game control. In the roaming state, players could interact with various objects, seamlessly transitioning into the interact state upon interaction. The interacting state implemented a singleton class for efficiently managing the dialogue system, which displayed images and allowed for choices with unique outcomes, adding depth and variability to the narrative. In the fighting phase, a music system was added using Unity's ScriptableObject to create customizable scales, enhancing the gaming experience with a unique musical element.

The project aimed to incorporate ten key elements of the GBL design model, including game goals, mechanics, interaction, freedom, game fantasy, narrative, sensation, game value, challenge, and mystery. The element of sociality was intentionally omitted since no social functions were part of the project scope.

Testing Phase

During the testing phase, the game development moved into its final stage, with testers thoroughly evaluating the nearly finished product. The assessment focused on measuring how effectively the project taught music theory concepts to players. The Serious Games Evaluation Scale (SGES) by Emmanuel, Penelope, Polyxeni, & Ioannis (2019) was used to comprehensively analyse the game's educational impact and overall quality.

Deployment Phase

In the deployment phase, the project was completed and exported as an executable file. It was then uploaded to Google Drive, making it easily accessible for users to play.

Review Phase

In the review phase, feedback from the testing evaluation is analysed using each factor from the Serious Games Evaluation Scale (SGES) to calculate mean scores and frequencies.

This process provides a comprehensive, data-driven understanding of the project's performance and user feedback.

RESULT AND DISCUSSION

This project evaluation aimed to assess how effective a turn-based RPG is for learning music theory. Factors from Emmanuel, Penelope, Polyxeni, & Ioannis 's (2019) Serious Games Evaluation Scale (SGES) were used, including perceived learning effectiveness, relevance, adequacy of the learning material, and motivation. These factors were used to evaluate how well the project facilitated music theory learning. The mean for each factor was calculated to determine the project's overall effectiveness. This evaluation provided a comprehensive understanding of how each factor contributed to the project's success in meeting its objectives.

Perceived Learning Effectiveness Factor

The Perceived Learning Effectiveness factor in SGES evaluates six aspects (E1 to E6) related to learning music theory through the game. E1 assesses the ease of learning, E2 compares the simplicity to traditional methods, E3 measures interest, E4 tracks knowledge gain, E5 evaluates grasping fundamentals, and E6 examines the usefulness of the knowledge acquired. Data in Table 2 shows that most respondents found the game simplified learning (E1), preferred it over traditional methods (E2), and found it engaging (E3). They also agreed it improved their knowledge (E4) and helped them grasp concepts quickly (E5). However, fewer found the content useful in real-world applications (E6). The average mean score of 4.45 out of 5 indicates the project successfully met the Perceived Learning Effectiveness factor, showing a strong consensus among respondents about the game's engaging and impactful learning experience for music theory.

Table 2: Mean Score and Frequency of Perceived Learning Effectiveness Factor

Factor	Code	SD	D	N	A	SA	Mean	Standard Deviation
Perceived Learning Effectiveness	E1	0	0	1	9	9	4.42	0.59
	E2	0	0	2	6	11	4.47	0.68
	E3	0	0	1	6	12	4.58	0.59
	E4	0	0	0	9	10	4.53	0.50
	E5	0	0	3	8	8	4.26	0.71
	E6	0	1	6	6	6	3.89	0.91
Average							4.45	

Perceived Relevance to Factor

The Perceived Relevance factor in SGES includes three codes (R1 to R3) that assess the project's alignment with player interests, relatability to everyday life, and relevance to prior knowledge. Data from Table 3 shows that most respondents found the project highly relevant to their interests (R1), somewhat relatable to their experiences (R2), and relevant to their prior knowledge (R3). The average mean score of 4.23 out of 5 indicates the project successfully met this factor, with respondents generally agreeing that the game provided a relevant learning experience for music theory.

Table 3: Mean Score and Frequency of Perceived Relevance to Factor

Factor	Code	SD	D	N	A	SA	Mean	Standard Deviation
Perceived Relevance to	R1	0	0	1	12	6	4.26	0.55
	R2	0	0	5	4	10	4.26	0.85
	R3	1	0	0	12	6	4.16	0.87
Average							4.23	

Perceived Adequacy of the Learning Material Factor

The Perceived Adequacy of the Learning Material factor in SGES includes three codes (R1 to R3) that assess difficulty in remembering information, complexity of exercises, and comprehension of material in the game. Data from Table 4 shows that most respondents did not find it difficult to remember information (R1), found the exercises to be manageable (R2), and did not struggle to understand them (R3). The average mean score of 3.92 out of 5 indicates the project successfully met this factor, with respondents generally agreeing that the game provided an adequate learning experience for music theory.

Table 4: Mean Score and Frequency of Perceived Adequacy of the Learning Material Factor

Factor	Code	SD	D	N	A	SA	Mean
Perceived Adequacy of the Learning Material	A1*	5	9	3	0	2	3.79
	A2*	6	9	2	1	1	3.95
	A3*	6	7	3	2	1	3.79
	A4	0	0	1	14	4	4.16
Average							3.92

Perceived Motivation Factor

The Motivation aspect in SGES includes three codes (M1 to M3) that assess the game's ability to capture attention, reluctance to learn more about music theory, and sense of demotivation while playing. Data from Table 5 shows that most respondents did not find the

game ineffective in capturing their attention (M1), were not unwilling to learn more about music theory while playing (M2) and did not feel demotivated during the gaming experience (M3). The average mean score of 3.92 out of 5 indicates the project successfully met the Perceived Adequacy of the Learning Material factor, with respondents generally agreeing that the game provided an adequate learning experience for music theory.

Table 5: Mean Score and Frequency of Motivation Factor

Factor	Code	SD	D	N	A	SA	Mean
Motivation	M1*	9	6	1	2	1	4.05
	M2*	10	4	3	2	0	4.16
	M3*	12	4	1	1	1	4.32
Average							4.18

Overall Findings

The total average was calculated from the means obtained in the previous analysis and converted to a percentage to determine the project's overall success. With a notable figure of 84.0% in Table 6, the project was effective in teaching music theory concepts.

Table 6: Overview of the Mean Value for Each Factor

Factor	Mean
Perceived Learning Effectiveness Factor	4.45
Perceived Relevance to	4.23
Perceived Adequacy of the Learning Material	3.92
Motivation	4.18
Total Average	4.20
% of total average	84.0

Discussion

The project successfully achieved its objectives, which were to create a turn-based role-playing game for learning music theory and assessing its effectiveness. The Serious Games Evaluation Scale (SGES) questionnaire was used for evaluation, demonstrating the project's success in integrating game mechanics to enhance the learning experience for music theory.

Several limitations were identified in the project. Firstly, the game is exclusive to Microsoft Windows, potentially limiting its visibility as many prefer mobile devices. Cross-platform compatibility could address this limitation and reach a broader audience. Another limitation is the scope of knowledge covered in the game, which currently focuses on notes and scales. Expanding this to include more music theory concepts could enhance the game's educational value. These limitations provide insights for future iterations, highlighting the need

to improve platform accessibility and expand educational content for a more versatile and engaging project.

While the project has met its objectives, there are areas for improvement. Releasing the game on platforms like Android, iOS, or Switch could expand its reach. Broadening the game's scope to cover more music theory concepts would enhance its educational value. Increasing the map size and adding new secrets to discover could boost player engagement. These improvements offer promising directions for future development, making the project more versatile, educational, and engaging for a broader audience.

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