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Composing Music Through Tile-based Games

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Abstract—In the realm of music we have multiple examples of successful rock stars, composers and producers who describe themselves as self-taught. This suggests there might be a demand in formal music education for learning technologies that support students' self-propelled discovery. In this theoretical work, we explore the design space of educational music composing games that would allow students to explore and learn music theory concepts at their leisure. We designed four unique tile-based music creation games based on popular contemporary video game genres, and evaluated them from the perspectives of learning and musical expression. This study opens up new avenues in music composing game design, and offers examples of some ways in which games can be harnessed as vehicles to learn music theory and composition.

Index Terms—Music education, music, mathematics, discrete logic, tile-based games, video games

I. INTRODUCTION

"Every time we teach a child something, we keep him from inventing it himself. On the other hand, that which we allow him to discover for himself will remain with him visible for the rest of his life." - Jean Piaget [1]

Jean Piaget, attributed as one of the pioneers of constructivist approaches to learning, was an advocate of learning through experimentation. Piaget saw the role of a teacher as being a wayfarer, someone who guides students by offering them materials and how to use them. He argued that students should be allowed discover and construct knowledge themselves as opposed to being taught things directly [1]. From these core ideas, multiple pedagogical approaches have evolved, including constructionism [2]–[4], constructivism [5] and empirical modelling [6]. The ideas articulated in these theories are relevant in music education, where there exists a plethora of relationships that can be formalized and presented in various ways, and learned through experimentation. In this study, building off Piaget and the pedagogical principles articulated in follow-up work, we explore how music composing and theory could be learned through tile-based games.

Tile-based games offer a suitable background for learning music theory and composition because these games contain discrete spaces that players interact with (i.e. the tiles), which can be connected to discrete aspects of music such as rhythm or pitch. The more dimensions a tile-based game has, the more aspects of music can be represented. We can e.g., represent one bar of music as a vector (x,y,z) where x corresponds to pitch, y corresponds to the sound and z corresponds to the note velocity. While previous research has explored some opportunities for composing music via games (see e.g. [7]) and there are also industrial examples such as Mario Paint Composer [8] and Music by Jester and Codemasters, so far only little work has been done on music composing with tile-based games. In this work we approach this research area through the perspective of design, which is a suitable approach when probing previously unexplored areas. Designs also have inherent scientific value (e.g., through elucidating the paths and practices leading to a design and the designs themselves) [9], [10] and through the design processes, we are able to explore and document some of the dynamics involved in creating music through tile-based games. It is worth noting that this current conceptual study is not aimed for producing generalizations, proving which design approach is the best nor empirically verifying the effectiveness of the designs. Rather, it is a preliminary exploration that may lead to the discovery of new previously explored areas [11], particularly in educational technology design.

Regarding the research process, we loosely follow the annotated portfolio approach [12] and create four designs which we describe in this work. While the contributions of this article are theoretical, they lay the groundwork for future empirical studies. The rest of this study is structured as follows. First we review previous research on music education through games and tile-based games. We then present and elaborate on four music composition game designs. Finally, we conclude the study by comparing the designs with each other, presenting the theoretical contributions of this work and discussing the limitations and future work avenues.

II. THEORETICAL BACKGROUND

A. Previous research on games for composing music

Much of the academic research on the thematic area of music and games has focused on the background music and soundtracks of video games as opposed to harnessing games for music creation. The studies in this domain include works on procedural and generative music creation [13]–[15], adaptive and dynamic music systems [16], [17] and the role that music has on games [18]–[20] among others. Regarding procedural and generative music, the research so far has provided examples of ways to algorithmically compose and generate music and sounds for games, and this has often been linked with options to adopt the music to match gameplay [16]. These types of systems are relevant for this study, since in order to work, they require a presentation of the game world in a way that allows us to match music with in-game events. Through adaptive music systems, game designers are able to select music that highlights specific aspects of the game, accentuating the player's emotions or even providing audio cues of events that are about to happen [17]. One example of using adaptive music to alert players is "video game boss music" i.e., music that plays when a boss or enemies are close [19]. In an open world game the presence of such music can indicate to players that they are in danger and should prepare for battle. It is also typical to accentuate music through other sensory experiences which we see prominently in e.g. music videos and stage lighting at rock concerts [21], but also video games.

Moving beyond generative and adaptive music systems, there are a few studies which focus on composing music within or through video games. One example is *Harmony Hippo*, a mathematics-learning music composition game aimed at primary school-age children, where players connect notes from a musical scale to rhythms and creating music this way [7]. Another example is *Mario Paint Composer*, a system that came with the game *Mario Paint* published for Super Nintendo Entertainment System (SNES) in 1992. *Mario Paint Composer* is based on the traditional sheet music notation, but instead of notes, players place sound icons (sampled sounds) on the note coordinate grid, creating music this way [8]. Having the game resemble sheet music can help players transfer their knowledge of the music perhaps more easily to the context of classical music, and *Mario Paint Composer* has maintained some sort of a cult following among game music enthusiasts to date [8]. In addition, there are some tools such as *Music* (by Jester and Codemasters) and *Hyperscore* [22], [23], which can be classified as gamified music composition tools. The idea in the case of *Hyperscore* is to offer a more visually attractive colorful representation of music, making composing more accessible to children, and helping them visualize the various sounds in the score better.

Zooming away from music composing games we have the higher level category of music games, which are by and large designed in a way where the player performs music instead of composing new original songs [24]. Examples of these games

include *Guitar Hero*, *Rock Band*, *Wii Music* and *Rocksmith* and *Donkey Kong Jungle Beat* [24]. Oftentimes these games have their own controllers i.e. drums for *Donkey Kong Jungle Beat*, a guitar mock for *Guitar Hero* and a microphone for games such as *SingStar*. While these games can bring learners closer to music, they lack depth in scaffolding an understanding of music theory and underlying structures of music. In fact, games such as *Guitar Hero* simplify songs to match five buttons that roughly correspond to the pitch of notes, leading to a misrepresentation of pitch, which can even be harmful for learning [25]. There are also rhythm and dance games such as *Fitness Boxing*, *Beat Saber* and the *Just Dance* series, where the focus is more on rhythm, choreography and exercise, and less on the music itself [26], [27]. Finally, we have video games where music or a musical instrument is in a central role in the gameplay. Examples include *Loom*, *Wandersong* and the *Legend of Zelda* series, where in games such as *Majora's Mask*, *Ocarina of Time* and *Wind Waker*, the player is required to learn songs to proceed in the game world [28].

B. Tile-based games

The concept of a tile-based game is not related to video game genres. Rather, it is a word that can be used to describe the technical implementation of the game. In this work, we define tile-based games as games where the underlying game world is presented to players as discrete tiles (see e.g. [29, p. 10]), whereby the tiles can be interacted with.

Originally, tile-based games were a practical design choice, as they offered several development advantages. Dividing the game world into a grid of tiles simplifies game design, and managing levels and maps becomes easier. The tile structure supports consistent and modular design. Making use of a limited set of tile designs to create the game world is also resource-efficient and helps save memory, as tiles can be reused in different configurations [30]. Likewise, in early gaming systems, tile-based graphics were also more efficient in terms of performance and rendering [31], which made it easier for games to run smoothly on hardware with limited capabilities.

Moreover, using tiles gives a structured and predictable way to create and present game environments. The gameplay is simplified, as opposed to e.g. *League of Legends* [32], providing clear boundaries for characters and objects. Tasks such as path-finding also become more straightforward in systems with limited resources [33]. Game designers can also add new content or levels simply by creating and arranging tiles. This way, a game can be expanded without significant coding or asset creation. All these aspects make tile-based games a suitably simple yet versatile context for creating music.

III. FOUR TILE-BASED MUSIC COMPOSING GAME DESIGNS

For this study we designed four different tile-based music composing games. The method for coming up with these designs was as follows. First, we reviewed the previous

TABLE I
DISPLAYING BASIC INFORMATION OF FOUR TILE-BASED GAME GENRES.

Genre	Description	Example games
Side-scrolling 2D platformer / infinite runner (vertical)	These games are an old genre and major franchises such as Sonic, Mario, Kirby and Metroid were originally these types of games. Recently we've also see endless runner mechanics mixed in.	Super Mario Bros., Dead Cells, Super Metroid, Sonic Advance.
Scrolling shooter	These games were popular in arcade halls in the 1980's, but there are some recent entries in the genre such as Sky Force. The player controls a character on the bottom end of the screen and shoots at objects appearing typically from the top of the screen.	Borderline, Xevious, Tyrian, Ikari Warriors, Bullet Hell Monday, Sky Force.
Tile-based roguelikes	These games are characterized by exploring a tile-based world more freely than the side-scrollers, whereby the player moves through often pseudo-randomly generated game worlds in hopes of progressing to the final goal.	Hades, Binding of Isaac, Rogue, NetHack.
Tile-based strategy games	These games remain popular with series such as Civilization selling millions of copies every time a new installment is released. Players have a fixed tile-based world where they strategically position, move and command a set of units.	Civilization-series, Advance Wars-series, Into the Breach, Wargroove, Lost Frontier, Chess.

literature on music games and composing solutions (e.g. [34]) and familiarized ourselves with tile-based games as presented in the previous section. Second, we engaged in a non-linear creative design process with the aim of coming up ways to present pitch and rhythm, but also possibly other elements of a musical score (such as note velocity, voice, timbre and tone), within the selected genres of tile-based games. In this process we want back and forth between our designs, drawing mockups of what they would look like, and refined them to ensure they enabled players to compose music. Third and finally, once we had four designs ready, we reflected on them from the perspectives of what kinds of musical freedom they offer and what mechanisms they have for supporting the learning of musical structures and theory. This final part we present in the Discussion Section. Next, we elaborate on these designs by describing how they function and what kinds of learning mechanisms and composition outcomes are associated with them.

A. Design #1: Tile shooter – music bazooker

The tile shooter design is depicted in Fig. 1. This design is based on the vertical side-scroller shooting game genre and draws inspiration from games such as Tyrian and Sky Force. Players face a barrage of musical notes approaching their base, and they must target and destroy those notes that they do not want to hit their base. Notes that do manage to reach the ground level must be dodged, and their impact will leave a mark on the base. Each wave of notes is associated with a time (measured in music with bars), whereby the first row of notes is the 1/4 of the first bar, the second row the 2/4 of the first bar and so forth. By choosing which notes to keep (and dodge), players are able to control the final composition that is created through playing the game. The game could be modified to offer players more control over what notes drop down or to have bullets that lower or raise the pitch of the notes by half a step.

The challenge in this game comes from the speed at which the notes drop from the sky, and the more control players wish to have over their composition, the more challenging it is. Mistakes that players make during the play can be heard afterwards in the composition. As players progress in the game they may unlock new musical scales and sounds, or even

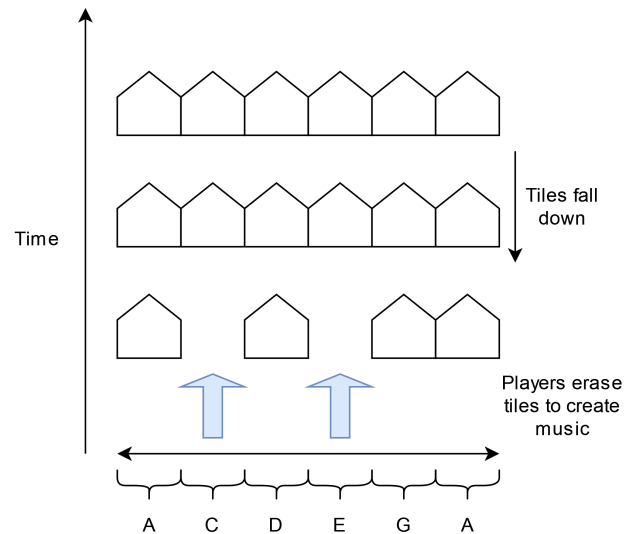


Fig. 1. Showing the design of the tile shooter. Players can eliminate tiles on each row and the remaining tiles will play music once they reach the end goal. After each level, the composition can be listened to.

combine two different compositions together to create songs with multiple instruments. As the game is dynamic, it might make players accidentally choose notes they did not intend to choose, resulting in perhaps surprising compositions, helping the learner get out of rigid routines they may have developed in their creative work.

B. Design #2 The composing side-scroller roller

The second design is based on the infinite runner platformer genre and draws inspiration from games such as Super Mario Bros. Subway Surfers and Dead Cells. Here we position time on the x-axis and pitch on the y-axis, similarly to the sheet music notation, piano roll and other similar visualizations. The only difference is that now players also play a platformer game while composing the song. The screen keeps scrolling forward and players cannot move back and forth at will, instead, they move forward at a steady pace. This ensures that no terrible dissonances will be created as when players jump and generate multiple notes, all these notes will be divided in time creating appoggiated music. The core design is displayed in Fig. 2.

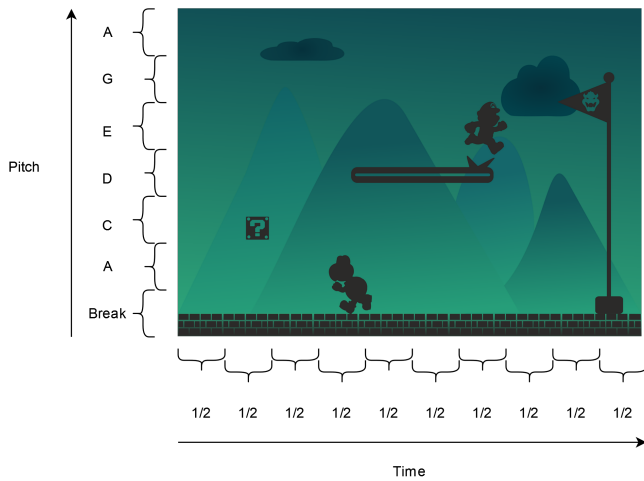


Fig. 2. Showing the design of the side scroller composing game. Players move through levels, and as they jump, they hit notes on specific tiles. These notes, and when they were reached, are stored to generate an original soundtrack of the player’s journey through the level.

This design limits players’ freedom of expression more than the previous one. It is geared towards creating compositions that are heavily arpeggiated (i.e. instead of playing a set of notes simultaneously as a chord, they are spread out over time), although platforms in the game do allow players to also create single note runs. Players may jump small jumps for small arpeggios and larger jumps for larger arpeggios. There are obstacles that players have to dodge leading to further limitations in their creative expression, but at the same time, similarly to the previous scenario, the gameplay challenge can help players break free of existing routines and thought patterns, creating music that they would otherwise not have made.

C. Design #3 Rogue-like non-linear music integrator

The third design is based on rogue-like games where the player’s character is viewed from top down either at a 90 degree angle or a slightly tilted angle. As such it takes inspiration from games such as Hades or Blizzard Entertainment’s Diablo-series. In our music composing version of this game (see Fig. 3) we assign musical notes to the tiles that form the playground in these games. We show the tiles as hexagon-shapes, but they can also be other shapes. Each row of tiles represents a specific point in time and the tiles in this row represent musical notes. Unlike the previous two designs, here the player is free to move back and forth between the tiles, creating music in the process. When they arrive back to a square that note is deleted. When coming up with a composition that players think will sound good, they hence need to plan their route to be such which produces the best sounds.

This design offers more creative freedom to players than the previous two designs, but at the same time, can be even more challenging as in addition to minding the composition, players need to destroy enemies, farm loot for equipment

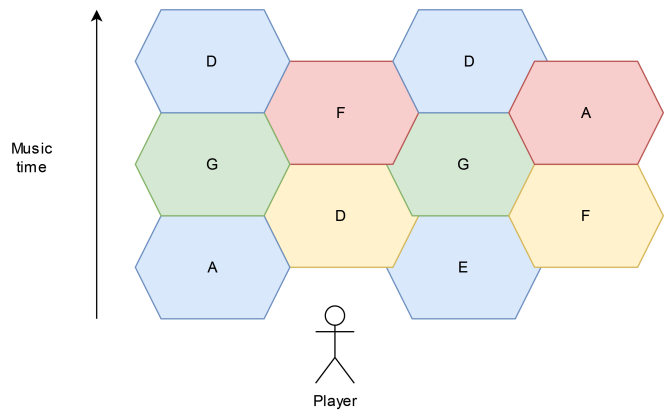


Fig. 3. Showing the design of a tile-based non-linear music composing game. The player starts to move along the level, which is color coded to visualize players which beat they are on. Players can move back and forth, activating hexagon-shaped music tiles, and when they ultimately finish the level, the music they left behind will play.

and perform other tasks associated with rogue-like games. The individual levels can be kept short to ensure players are able to draw the connection between their movement and the resulting composition, but multiple levels can be chained together, ultimately resulting in a longer composition.

D. Design #4 Strategic music positioning game

In the fourth and final design we drew inspiration from titles such as Advance Wars, Fire Emblem and chess. Players start out with an empty board, or a limited set of pieces on board, each of which represent a musical instrument or a sound. The game is turn-based, and each turn represents one quarter of a bar of music. In other words, opposed to the previous three designs, here time/rhythm is separated from the in-game tiles allowing us to include more musical elements to the composition than just the rhythm and the pitch. In this game, the pitch of the notes is determined by the position of the units along the horizontal axis. The player positions their units on the board one at a time, resulting in more and more harmony (or dissonance) as they do so. The velocity of the notes is low at first, but as the player advances with their pieces, the velocity increases. This means that the compositions resulting from this type of a design will eventually start quiet, getting louder and louder towards the end as the battle escalates and becomes more frequent. We showcase the rough design of this in Fig. 4. It is also noteworthy that as players place various units on the board, they generate music with multiple voices (such as piano and trombone).

This design again results in widely different types of compositions than all the previous games so far. First of all, they will be more nuanced as in addition to the two dimensional compositions of the first three designs, here we add the dimensions of velocity and sound to the mix. Second, the compositions have no fixed time as opposed to the other scenarios, and can take a shorter time or longer one. Third, the compositions here are closer to data sonification [35] than the other scenarios. Since it is a strategy game, and the game itself

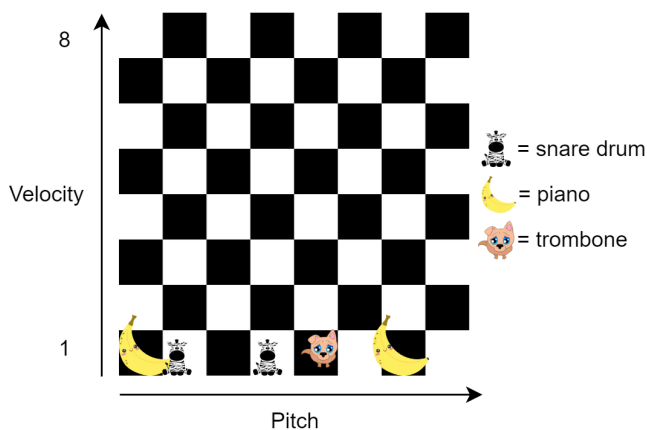


Fig. 4. Showing a 8x8 board where the vertical row corresponds to note velocity (i.e. how loud it is) and the horizontal row corresponds to note pitch. The game is turn-based, and each turn presents musical time. Multiple instruments can be deployed at time and it also supports harmony creation.

will have goals, players might not have the music in mind as they play. Rather, they get to hear what their playing sounded afterwards. While this is true for all the four designs presented in this paper, we argue that it is particularly relevant here as the setting is more complex. The scenario does not offer musical and creative freedom, and it does guide the compositions rather heavily.

IV. DISCUSSION

A. Comparing the four designs in terms of learning and composition outcomes

All the four scenarios have their advantages and weaknesses in terms of musical expression, challenge and educational outcomes. We predict they can spark musical creativity, but also serve as tools for implicitly learning music-related learning goals. Each scenario has a slightly different emphasis and focus on music theory and the underlying musical structure behind the composition. In designs #1, #2 and #4 players learn to link the passage of time in the game to the passage of time in the composition, whereas in design #3 they have peace to manipulate time as they can also move backwards in it. Design #2 is close to the piano roll and sheet music notations as pitch is increased by changing elevation and the rhythm is determined by horizontal position. Design #1 can be seen as an introduction to harmony, since the falling down notes invite players to try and see how various notes sound together. This scenario can also be modified to allow players a limited number of bullets per wave, directing them even more heavily towards harmony. Design #2 on the other hand is all about arpeggios as no two notes can be played together. Design #3 can be either or, and this scenario offers learners the most creative freedom.

Design #4 offers learners the opportunity to move beyond the basic components of pitch and rhythm, introducing the concepts of velocity and sound to the composition process. While these four elements are still not nearly enough to

describe music as we know it today, they are a step towards learning more of the complexity of music. For this reason, Design #4 is most suitable for an older audience. In terms of musical expression we argue that Designs #1 and #2 are most suitable for beginners to learn how music is made and what the basic components are, whereas Designs #3 and #4 can be a step forward in creating more complex compositions.

It is noteworthy that none of the four game designs presented here is a fully fledged digital-audio-workstation (DAW) [34] and these should be viewed as fun games that can help novice musicians to be introduced to music composing. We argue from the vantage point of Piaget, Papert, Beynon and others [1], [6], [36] that such games can be helpful in allowing young children to form an understanding of music themselves without much guidance. The critical aspect is whether students learn to draw the connection between events in the game and the music they hear. To boost this connection, we can employ visual assistance such as replaying the game afterwards showing how the music was made, or by including the sounds generated by the player to the actual playing situation.

B. Theoretical contributions

The theoretical design underpinnings of the four scenarios were related to linking learning attributes to gameplay and supporting deliberate practice [37] as well as creating "objects to learn with" [6], [36] supporting learning through experimentation [1]. Due to the lack of empirical investigations, the main contributions relate to opening a new ideas in the design space of music composing games and in demonstrating new possible artifacts. The ideas show potential in the democratization of music education, as through such games music education can become more accessible to the general public. Such games could also serve to reduce stigma [38], and in our case may help music composing and music theory feel less scary as they are introduced in a fun and playful setting.

The four designs can be viewed as inspiration for music education material designers [39]. Allowing students to create their own songs can provide them with opportunities of self-actualization [40], and perhaps also allow them to better understand and appreciate classical composer masters such as Bach, Beethoven, Sibelius or Chopin as well as contemporary maestros in video game music such as Koji Kondo, Nobuo Uematsu, Mick Gordon, Alexander Brandon and Motoi Sakuraba.

C. Limitations and future work

As the main contributions of this study related to theoretical examination of the proposed designs, the logical next steps are implementing the designs and conducting user studies to further examine how the proposed designs play out in practice. The four scenarios could be tested in parallel with existing tools or a digital audio workstation (DAW) serving as a control scenario to see how the games differ in terms of (1) player enjoyment; (2) resulting compositions; (3) freedom of expression; (4) challenge; and (5) learning of music theory. Other areas of exploration include testing for the games

leading to an improved ability to listen to music and hear the notes that are playing and whether the games can help players get acquainted with music terminology (e.g. arpeggio, crescendo, pianissimo, forte).

We encourage future researchers to continue work on creating, but also testing, tangible musical games through which music theory, structure and composition can be learned. We see music in its many forms as an important part of humanity, since music is everywhere in our lives from dancing and movies to games and parties. For this reason allowing students to discover the joy of music in a playful manner is important, and doing so in a creative way that allows students to not only understand, but also create new, aligns with the philosophy of Piaget:

"The principal goal of education is to create individuals who are capable of doing new things, not simply of repeating what other generations have done." -Jean Piaget

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