De La Salle University

THS-CS1 [ ] FINAL [✓]

College of Computer Studies

COLLEGE OF COMPUTER STUDIES
SOFTWARE TECHNOLOGY DEPARTMENT

REVISIONS APPROVAL SHEET

Term 3 AY 2019 – 2020	**Proponents:**	
THS-CS3 Thesis Title:	Paolo Miguel Ato Mart Henrick Gamutan Antoine Mikhael Salcedo Josh Cezar Valencia	
FireflyX:Designing Interactions for a Mobile Musical Learning Tool for Children	**Date/Time Defended**	**Date/Time Submitted**
	09/11/2020 6:00pm-7:00pm	

Adviser	O for acceptance ⊗ for approval	**Accepted/Approved**		
		Signature	Date	Remarks
Jordan Aiko Deja			September 24 2020	reviewed and endorsed for panel review

Panel Members	**Checked**		**Approved**	
	Signature	Date/Time	Signature	Date/Time
Rafael Cabredo		9/28/2020 5:05pm		9/28/2020 5:05pm
Ryan Austin Fernandez		09/28/2020 1:23 PM		09/28/2020 1:23 PM
Arturo Caronongan		09/29/2020 6:28 PM		10/01/2020 6:32 AM

Recommendation of Lead Panel: **Revise and recheck by ALL panel members**

Revisions (use the back page if necessary)	Page # on the revised document
“difficult to learn” -> added comma, “rhythm, pitch” -> added comma, Improved the wording of the abstract takeaways	ii
when talking about the firefly model it uses the small ‘f’ vs. when talking about the application FireflyX uses ‘F’	1++
Changed “on how to make” to “making”	2
“sound,” -> removed comma, “these technologies” -> added comma, “sandbox environment” -> added comma	3
changed 5 to five, “musical theories” -> added comma,	5

THS-CS1 [ ] FINAL [✓]

"rhythm, pitch" -> added comma	
"modes," -> removed comma	8
"Human factors arises." -> changed to lowercase	10
"the background, Figure 2.4 shows a sample" -> fixed run on sentence, "algorithm is" -> deleted is, "like, and in effect increasing a users motivation to learn programming" -> rephrase this sentence	12
"questions and" -> added comma, "answered correctly" -> added comma	15
"Learning a simple song" -> changed to lowercase	16
"having him/her reproduce" ->stated what the participant is reproducing.	17
"simulates 3" -> changed 3 to three, "seen in 3" -> changed 3 to three	19
"harpsichord, double bass" -> added comma, "a keyboard" -> added comma, "by (Paule-Ruiz et al., 2017)" -> changed to \citeA	20
"has 4" -> changed 4 to four, "are 3" -> changed 3 to three, changed "composing" to "composition", changed "inspiration on" to " inspiration for"	21
"Computer Interaction, Interaction Design" -> added comma	25
"into 5" -> changed 5 to five	28
"The principle provided to answer is to provide"->reworded the sentence "Principle to help" -> changed to lowercase, " A Principle to help solve this issue is to make the menu choices finger friendly, since the problem lies on the ngers not always hitting the small details of the screen making interaction mechanisms like lists, buttons, menus, etc. finger friendly helps the use in having more control in the application" -> Separated these to two sentences, "will be used" -> changed to pat tense	30
"recommended 5" -> changed 5 to five	31

THS-CS1 [ ] FINAL [✓]

“Adults that children” -> changed to lowercase	38
“on the other hand” -> added comma, changed “encourages children exploration” to “"encourages the children to explore while”, “Evaluate impact over time, Make it practical for childrens reality, Personalize and Be mindful of skill hierarchies” -> changed to bullet form	40
“Augment human” -> changed to lowercase, “Design the ecology” -> changed to lowercase	41
“4 theories” -> changed 4 to four, “The 4“ -> changed 4 to four	45
“using these” -> deleted these “three of these seven tempo markings” -> indicated the 3 tempos we used	47
“3 phases” -> changed 3 to three	52
Updated Gannt chart	63
Changed 3 to “three” Provide a justification for choosing the tempos	65
Changed “Database” to “database”, Fixed Figure 5.2	67
Changed 3 to “three”	71
Changed 5 to “five”	77
Changed 2 to “two”, Changed 6 to “6”, Bulleted prior knowledge in music Added Usability Test Objectives subsection Added section “FireflyX Testing” Changed “Participant” to “Participant Recruitment” and moved it as subsection to “FireflyX Testing”	87
Changed “covid-19” to “Covid-19”	88
Removed “for task 2 and task 3”, Fixed Figure ??	98
Changed Portfolio to “portfolio”, Changed “And lastly” to “Lastly” Changed “AttrakDiff” to “Post-testing using AttrakDiff”	106
Added explanation for adapting Attrakdiff to be usable by kids	107

De La Salle University

THS-CS1 [ ] FINAL [✓]

Changed 5 to “five”	110
Labeled y-axis in Figure 6.30	111
Labeled y-axis in Figure 6.31, Labeled the measure and units in Table 6.4	112
Labeled y-axis in Figure 6.33, Labeled y-axis in Figure 6.32	113
Labeled y-axis in Figure 6.34, Labeled the measure and units in Table 6.5	114
Labeled the measure and units in Table 6.7, Added “,”	115
Labeled the measure and units in Table 6.8	116
Labeled the measure and units in Table 6.9	117
Fixed Table ??	120
Changed 3 to “three”, Changed “(Hourcade, 2015)” to “Hourcade (2015)”	123
Changed 2 to “two”	125
Added “, and”, “of”, Rephrased conclusion to summarize important key findings	127

- *This serves as the cover page of the revised document. Items listed should coincide with those listed in the defense evaluation sheet.*
- *Adviser **must** approve the revisions before its presentation to the panel. Otherwise panel members **must not** accept then revisions unless otherwise indicated in the revision sheet.*
- *Panel members sign either in the checked column indicating it has been checked or the approved indicating final approval.*
- *The lead panel is the last to sign and give the final recommendation*
- *Proponent must take note of requirements and deadlines set by the Department through the Thesis Coordinator.*

De La Salle University

FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children

A Thesis
Presented to
the Faculty of the College of Computer Studies
De La Salle University Manila

In Partial Fulfillment
of the Requirements for the Degree of
Bachelor of Science in Computer Science

by

ATO, Paolo Miguel B.
GAMUTAN, Mart Henrick A.
SALCEDO, Antoine Mikhael M.
VALENCIA, Josh Cezar L.

Jordan Aiko P. DEJA
Adviser

October 2, 2020

De La Salle University

The thesis entitled

FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children

developed by:

ATO, Paolo Miguel, B.
GAMUTAN, Mart Henrick, A.
SALCEDO, Antoine Mikhael, M.
VALENCIA, Josh Cezar, L.

are submitted in partial fulfillment of the requirements of the Bachelor of Science in Computer Science degree, has been examined and recommended for acceptance and approval.

Jordan Aiko P. Deja ______________ , Adviser

9/29/2020 ______________ , Date

De La Salle University

The thesis entitled

FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children

after having been reviewed, is hereby approved by the following members of the thesis committee:

Dr. Rafael Cabredo
Lead Panelist

October 2, 2020
Date

Mr. Ryan Austin Fernandez
Panelist

October 2, 2020
Date

Mr. Arturo Caronongan III
Panelist

October 2, 2020
Date

The thesis entitled

FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children

after having been recommended and reviewed, is hereby approved by the Software Technology Department, College of Computer Studies, De La Salle University:

Ryan Dimaunahan Chairperson Software Technology Department	Dr. Rafael Cabredo Dean College of Computer Studies
Date	Date

Document Sharing Policy

This document is accessible to the following:
In the event of two conflicting answers, the more permissible sharing will be followed.
This sharing policy is only applicable to the research document and not the other documents submitted, such as the brochure, and video presentation. ◎ if no ◉ if yes

Available to the general public	◎
Available only after the approval of at least one of proponents or the adviser	◉
Available only after the approval of all the proponents and the adviser	◉
Available only to those bound by a confidentiality agreement	◉
If the proponents and adviser are not available, the department chair can decide to share the document	◉

Paolo Miguel B. Ato
Proponent

Mart Henrick A. Gamutan
Proponent

Antoine Mikhael M. Salcedo
Proponent

Josh Cezar L. Valencia
Proponent

Jordan Aiko P. Deja
Adviser

Acknowledgements

First, we would like to express our gratitude towards our adviser, Mr. Jordan Deja, for guiding us in accomplishing our thesis. His knowledge about Human-Computer Interaction definitely gave us a lot of learning opportunities.

We would also like to thank our panelists, Dr. Rafael Cabredo, Mr. Ryan Austin Fernandez, and Mr. Arturo Caronongan III, for helping us improve on our thesis. Their insights and feedback were valuable to this research.

Our thesis would not be possible if not for the music experts who guided us on how they taught children and in explaining to us musical concepts. Not only that, they also helped us assess and evaluate outputs which were crucial to our thesis. With that, we would like to thank Mr. Juan Carlo Magsalin and Ms. Victoria Regalado-Abadam for lending their time and expertise in music and how to evaluate children outputs.

Likewise, we would like to thank Ms. Chelsea Jimenez as the main artist for our application and Ms. Adrienne Soliven for designing parts of FireflyX. Also, we would like to thank Mr. Joshua Manzano for also providing help and advice in the research.

Lastly, we would also like to thank our research assistant Mr. Antonello Santos for helping us formalize our research and helping us design our initial mockups.

Abstract

Music has many complex properties that make it difficult to learn, especially for children. Various innovations have been introduced to make the music learning process exciting for them. However, much has yet to be understood on how children and their innate playfulness can be used as the best motivation in helping them learn difficult concepts in music. In this research, we first investigated how music experts teach children at an early age concepts such as tempo, rhythm, pitch, and notes. Second, we rapidly developed a mobile musical application across several iterations and tested them with our participants. Third, we performed a user study to evaluate the application's usability, the children's learning performance, and music quality of their outputs. We found specific traits and activity patterns such as *Nodding of head while listening to firefly*, *Convenient visual matching through playful cues*, *Ignoring their obvious mistakes*, and others. These are correlated with how children play and learn with music. These findings enabled us to uncover specific design affordances and guidelines that may effectively teach and engage children in the long term.

Keywords: Human Computer Interaction, Music Representation, Sandbox Environment, Gestural Input, Usability testing, User Interface Design

Contents

List of Figures

List of Tables

Music is a science which must have determined rules. These rules must be drawn from a principle which should be evident, and this principle cannot be known without the help of mathematics. I must confess that in spite of all the experience which I have acquired in music by practicing it for a fairly long period, it is nevertheless only with the help of mathematics that my ideas became disentangled and that light has succeeded to a certain darkness of which I was not aware before.

rameau1722traite

Chapter 1

Research Description

1.1 Overview of the Current State of Technology

Music has been known to be an effective learning companion for children (McIntire, 2007). It is an integral part of their lives helping them understand the different complexities of life. Several applications and technologies have been developed to help children throughout their learning journey (Roschelle, Pea, Hoadley, Gordin, & Means, 2000).

Music can trigger many types of memories in children and can be used to engage with them at any time. This makes music play an important role in their education (Levinowitz, 1999). On the other hand, computers and digital applications have become part of a child's daily life which can lead the child to be more productive in doing educational tasks. By utilizing these technologies, music can contribute towards the overall learning of the child in certain knowledge areas like science and mathematics (Zaranis, Kalogiannakis, & Papadakis, 2013).

Music is also a complex cultural phenomena making it difficult to study as it has a wide variety of theories to learn (Byrd, 2009). One of the main reasons that makes it difficult is its many representations. Since music is considered as a form of art, composers have the freedom to make music in any way so that they can define it the way they want it to be (Byrd, 2009).

The difficulty in teaching a child to learn music is on making it enjoyable for them, as the learning comes from them exploring various instruments at an early age (Ghazali & Alam, 2005). This playful nature leads to them doing simple acts like singing and playing musical games which can serve as a foundation in giving them a basic idea on musical theories. Copying or repeating sound enables children to learn from different sound sources, giving them a sense of some musical rudiments like rhythm and pitch (McPherson, 2015).

Multimedia Technology has been widely used in the education of students especially in the field of teaching music (Tong, 2016). Examples of these technologies include applications such as Musilla Musical School (EducationalAppStore, 2017), which is an application designed to teach the principles of music to children. Another is Sesame Street Makes Music (EducationalAppStore, 2015), which is an application designed to help children explore instruments, tempo, and musical creativity. However these applications pose further opportunities for learning such as the limitations in accurate representations.

There are many different approaches that help in learning. One common way is children attending traditional schools as they use the instructional approach of learning where there is a teacher guiding them throughout the process. Another approach which is mostly unconventional in schools is the use of mnemonics where relatable associations are used to remember complex ideas (Putnam, 2015). Next is the sandbox approach where the child can playfully learn using a virtual sandbox environment on their own. Here, they discover by themselves the ideas by exploring and playing around the sandbox environment. We want to discover whether these technologies, such as implementing a virtual sandbox environment, can enable children to play, create and explore music.

The sandbox approach is implemented usually in a specific software platform. This provides control over the resources that the software or users can use (Prevelakis & Spinellis, 2001). Much like the literal sandbox where people can only use items inside it, such an environment allows users to only interact with what is provided to them (Goldberg, Wagner, Thomas, Brewer, et al., 1996). An example of a notable learning sandbox environment is Scratch . It is a visual programming language developed to deal with the problem of learning programming for novices, especially younger users (Maloney et al., 2010). It uses the sandbox approach to assist young people learn how to think creatively, reason systematically (Kalelioğlu & Gülbahar, 2014). Its implementation of the sandbox approach aids children in learning how to work successfully with others, and think ingeniously (Nodalo, Santiago III, Valenzuela, & Deja, 2016). Another notable learning sandbox environment is the Sonification Sandbox (Walker & Cothran, 2003). It allows users to independently map several data sets to timbre, pitch, volume, and pan, with full control over the default, minimum, maximum, and polarity for each attribute (Walker & Cothran, 2003). By using the features from Sonification Sandbox, we get to take advantage of these features.

OtoMushi, derived from its Japanese meaning where *oto* means sound and *mushi* means insect, is a platform for interacting with sound samples which is represented by insects developed by Andre (2010). Its sandbox environment allows a controlled canvass where users can mix virtual creatures applying scratching techniques to explore sound (Andre, 2010). It allows users to record sound when they speak. A tangible sandbox environment surface called smartskin by (Rekimoto, 2002) lacked responsiveness and that the resolution of the graphics were bad. In later iterations, OtoMushi was implemented on the iPad. By implementing it this way, children can play with the tool as if it was a virtual sandbox environment. With this, a child's playfulness can be exploited by allowing them to play with the tool as much as they want.

Music has many complex properties that make it difficult to learn. Children are also difficult to teach because they have a shorter attention span and require many repetitions when teaching music (May, 2013). Sandbox environments have been found to work on children since play is central to early childhood education and it also provides a safe yet playful environment suited for their learning (Bos, Wilder, Cook, & O'Donnell, 2014; Dalgarno & Lee, 2010). There are many music applications across several platforms that help in teaching music to children but there are only few that incorporate a sandbox environment that helps in accompanying their learning. With all these the tools and environments, this study aims to delve into the design of an interaction that will help children learn through a playful mobile interface.

1.2 Research Objectives

1.2.1 General Objective

This study aims to identify and model the human factors and behaviours that children exhibit when given the task of learning how to compose music with a mobile musical tool.

1.2.2 Specific Objectives

This research shall attempt to answer the following specific questions:

1. What activities do music teachers implement when teaching children music patterns?
2. What features can be designed to enable playful interactions when teaching children music?
3. What human factors do children exhibit when using the firefly and sandbox model?

1.3 Scope and Limitations of the Research

FireflyX is a virtual mobile music environment that will be developed on the iOS platform as a tablet application. With the use of the application, children can create their own music in an environment without the fear of breaking anything. The canvas will be able to house up to five virtual firefly models which can produce sound when they are released. It will only provide what is needed by the children namely starting the composition, composing the rhythm,pitch and tempo by configuring the firefly model, and playing the composition in the environment with the other created fireflies. We would be observing the children based on how they are taught musical theories, and our research will include children with different levels of music experience.

The firefly model will have a set musical features attached to its corresponding parts. These movable parts include the body, wings, and tail. Through the different parts of the firefly, children can configure the music through the use of interchangeable firefly model parts. These parts represent different musical rudiments of rhythm like clap-rest pattern, speed of sustain, and number of repetitions. It will also represent pitch and tempo as well. The firefly model can also represent one instrument and the target instrument for music creation is the piano due to its popularity with children. One firefly will represent one layer of the rhythm, pitch, and tempo also for this model music filters will not be included. Dotted notation will not be included as well. The 4/4 time signature will only be the used by all firefly models. When the children are done manipulating the parts of the firefly model, the firefly model is released and the sound is created by the combination of the parts is played.

The interactions the children will be limited to touch gestures that the mobile platforms can handle. Several touch gestures will be incorporated in the design to enable the children to play with the virtual firefly model. Such gestures include tap, drag, swipe, and flick. The target users of the application are children from ages 5-8. To evaluate the usability of the application the group will be evaluating the learning of children by giving them a set of instructions. After giving the instructions, we will be asking the music expert to evaluate the composition made by the child. We will also be observing children use the application and assess the applications usability afterwards.

1.4 Significance of the Research

This study attempts to design a usable mobile musical learning tool for children that incorporates computer-aided creativity, music elements and many others which can help children users to learn music theories at a young age. Additionally, the function of this tool will contribute in creating a child friendly interface for children to learn a hard concept like music.

This tool will help children learn music through the sandbox interface that the application presents. The study helps to offer other music application developers an idea on how to design sandbox environments and integrate them into music learning.

Development of tools like this would give a basis for instructional designers to develop mobile products on what to do and what not to do when designing and developing these kinds of applications. What this study can offer can be set as a benchmark on what the quality of these products when they will release onto the public would be.

Chapter 2

Review of Related Literature

This chapter discusses the features, capabilities, and limitations of existing research, algorithms, or software that are related/similar to the thesis.

2.1 CAI and Human Factors of Children in Learning Music

This section explains or show the human factors that are involved when teaching children. This will help us add features, and minimize the mistakes when designing and developing our application, FireflyX.

Technology has been evolving throughout these past years making it more accessible to people (Czaja & Lee, 2007). More and more schools have been adapting to the evolution of technology using them as tools for teaching (Aqda, Hamidi, & Rahimi, 2011). As such, CAI applications have been used in classroom settings for students in order to help them visualize objects and understand complex ideas at their own pace (Arnold, 1997).

CAI applications include guided drills, practice exercises, tutorials, simulations, computer visualization of complex objects, and computer-facilitated communication between students and teachers (Arnold, 1997; Christmann & Badgett, 2000). These kind of applications increase a student's access to information. They can also be adjusted to the preferences of the student. Many students benefit from the immediate responsiveness of computer interactions and appreciate the self-paced and private learning environment (Arnold, 1997).

With the evolution of technology, CAI applications are now available on mobile platforms such as tablets and smartphones. iPads and other forms of tablets are becoming a more common tool for teaching in schools these days (Papadakis & Kalogiannakis, 2017). An example of a mobile application where FireflyX can get some inspiration from is called SAMI which was developed by Paule-Ruiz et al. (2017). The visual cues they used for one of their modes were for memory development. An example of the game's interface is shown in Figure 2.1. This can be applied to firefly by designing visual cues that help children visualize music properties. Some examples of these visual cues that can be used in firefly are how fast the tempo is by the flap of the firefly's wings up and how the size of the body of the firefly can increase or decrease the volume. Since the visual cues play an important role in impacting the learning of the children, however previous studies mentioned that focusing too much on these visual cues for music related CAI applications can ruin sense of rhythm (Pennycook, 1985; Chung & Wu, 2017). Using well designed applications can attract the attention of children (Chung & Wu, 2017) and can also increase the pace of learning (Cohen, Hadley, & Frank, 2011). We can use this for FireflyX by designing the interface and using icons that are attractive to children. Figure 2.2 and 2.3 show examples of interfaces that children are more attracted to.

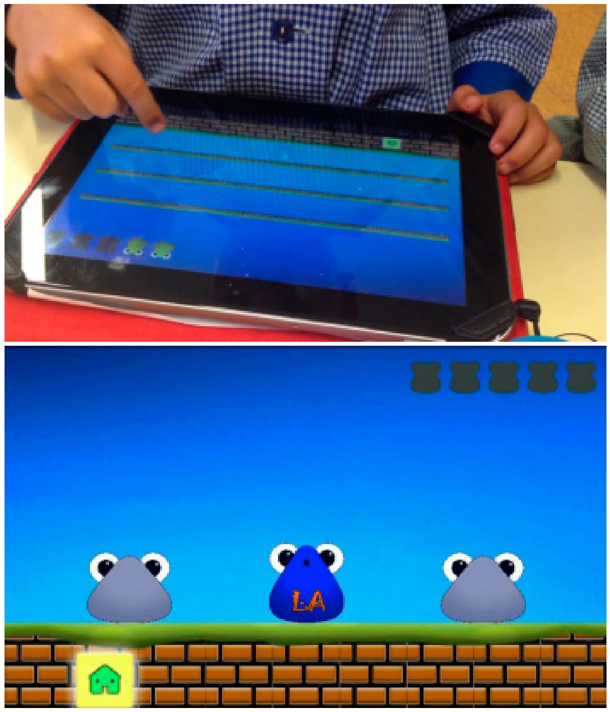


Figure 2.1: SAMI application (Paule-Ruiz et al., 2017)

Figure 2.2: iBUAT interface design (Ibharim & Yatim, 2014)

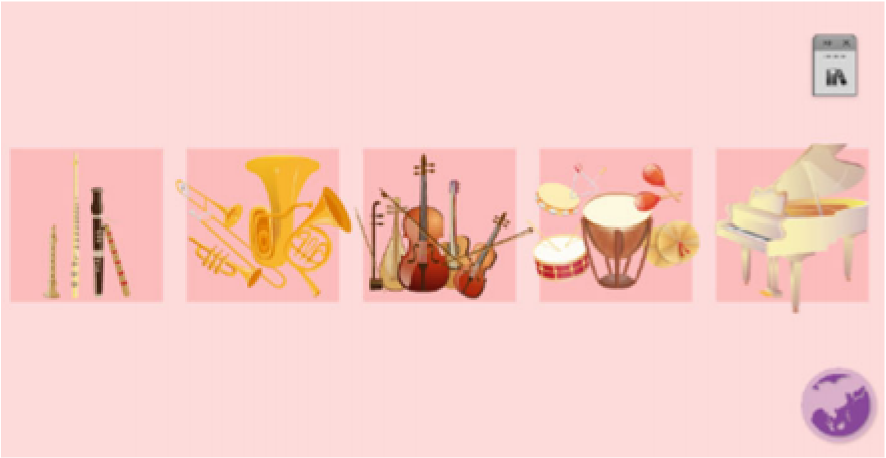


Figure 2.3: Icon design (Chung & Wu, 2017)

CAI applications have many uses inside and outside school settings, but there are limitations to using it. The results of its effectiveness and quality highly depends on the teaching material and instructional approach (Aqda et al., 2011). Making CAI applications must also consider using the student model, which is the acknowledgement of the presence and the limits of the knowledge of the user (Self, 1974). This means making multiple levels for difficulties of the CAI application for the user. The sandbox environment or sandbox approach is also another educational tool that lets the users explore the tool and learn how to use it on their own without any instructional procedures like CAI. This allows the application for the users to learn and explore FireflyX for themselves.

In order for CAI applications to be even developed in the first place, the concept of human factors must be understood. Human factors are defined as a discipline concerned with understanding the interactions among humans and elements of a system in order to be able optimize human well-being when interacting with these systems (Salvendy, 2012). Experts in the field contribute to the different tasks associated with these systems in order to make these systems have the ability to be compatible with the needs, abilities and limitations of people.

However, systems not optimized or worse for human interaction are also found to be detrimental to the people using it (Foley, Wallace, & Chan, 1984). For example a badly designed user interface may lead to negative outcomes. Negative outcomes include lower productivity, increased frustration and the need for redesigning to eliminate these outcomes. Due to this, the need for understanding human factors arises.

To help maximize the usability of an application, specific human factors related to the application's purpose must be observed. For example, if an application's purpose is to educate, then the factors that should be taken into account are the student's experiences and limitations such as reading capabilities (Radu, 2014). By knowing the users capabilities, an application can be better used by the users due to it being designed to the users needs or specifications. One specific application of this is scaffolding. Scaffolding is defined as something or someone that provides assistance when a child is acquiring a new skill during the execution of the actual skill itself (Strommen, 1998). However, scaffolding can come in many different forms but finding the most optimal form of scaffolding can be done by understanding the specific user needs and limitations.

Since FireflyX would be assisting in learning music for children, factors in education and children can should be taken into account. A study mentions that these factors include the children's imagination, their media generation and age differences (Oosterholt, Kusano, & de Vries, 1996). The importance of imagination comes in involving the children in the concept phase when discussing new products to them. Their generation is important as they wont respond much to things that have nothing to do with their generation. Also their generation usually also makes them have certain skills for using technology compared with other generations. Finally the age differences are important because a child grows fast mentally and physically making them have different views to each other if they are even a few years in age apart.

Table 2.1: Related studies on CAI and human factors of children in learning Music

Authors	Focus	Theory/Principle	Contributions/Details
Aqda, Hamidi, & Rahimi(2011); Chung, Wu, (2017; Arnold (1997); Barrow, Markman, Rouse (2008); Pennycook(1985); Cohen, Hadley, & Frank (2011); Self (1974); Czaja, & Lee,(2007)	Computer-aided Instruction	Advantages and disadvantages of using CAI	CAI gives student a private learning space, assists in teaching in the learning process of children. Good designed systems make it more usable for children. Poorly designed systems can have big negative effects. Difficulty of the instructions depend on the knowledge of the student.
Levinowitz (1999); Chung, Wu(2017)	Children Learning using Technology	Visualization Cues	We can use visual cues in order to represent music properties for firefly.
Salvendy (2012) Foley, Wallace & Chan (1984) Radu (2014); Stronmen (1998)	Human Factors	Definition of Human Factors	Human factors is a discipline that deals with understanding human interaction in order to maximize human well being when designing systems. Systems that do not think about these factors may lead to negative outcomes such as lower productivity. By researching and understanding the user needs or capabilities, the system can be better used by the users.
Oosterholt, Kusano & Vries (1996)	Human Factors	Human Factors of Children	Children have human factors related to education. These factors include the children's imagination, their media generation and age differences

De La Salle University

2.2 Sandbox Environment and other Dynamic Interfaces

This section provides an analysis on how different studies made use of sandbox environments. This will also highlight the results of testing these sandbox environments. It is important that we understand how to properly implement a suitable environment for the children and how to properly conduct testing on them while learning respect to these sandbox environments.

A sandbox environment is an environment, usually set to encourage playfulness, where users can use it as they like. A sandbox environment can be created by implementing the sandbox approach to a software where it is executed it in a specific operating system environment (Prevelakis & Spinellis, 2001). The sandbox approach also encourages users to play boundlessly, thereby increasing their curiosity and engagement in using the environment (Goldberg et al., 1996).

In the outside world context, children prefer playing games because it stimulates their minds and helps them think creatively (Martin, Fabes, Evans, & Wyman, 1999; Inal & Cagiltay, 2007). The same is also considered in a virtual environment such as an application, children are able to emulate playing outside by using a sandbox environment in an application. The use of apps have been found to increase visual stimulation, improve their navigation skills and be familiarized with music (Burton & Pearsall, 2016).

One example of an application that implemented a sandbox approach is Scratch. It allows users to drag and drop blocks to control 2D graphical objects moving on the background. Figure 2.4 shows a sample of the interface of Scratch. One of the most important feature of Scratch is that it is always live, meaning it requires no compilation step or run mode. Users can also add blocks while a script is running. This lets users be engaged with their projects and always be able to tinker with the blocks (Maloney et al., 2010). In the study of Ouahbi, Kaddari, Darhmaoui, Elachqar, and Lahmine (2015), high school students were able grasp programming concepts, and syntax was also not an issue for them. In addition to this, Scratch allows easy visualization of how the algorithm looks like, and it then helps in increasing the users motivation to learn programming (Erol & Kurt, 2017). By implementing these features, Scratch is able to provide users a sandbox environment that enables them to learn programming.

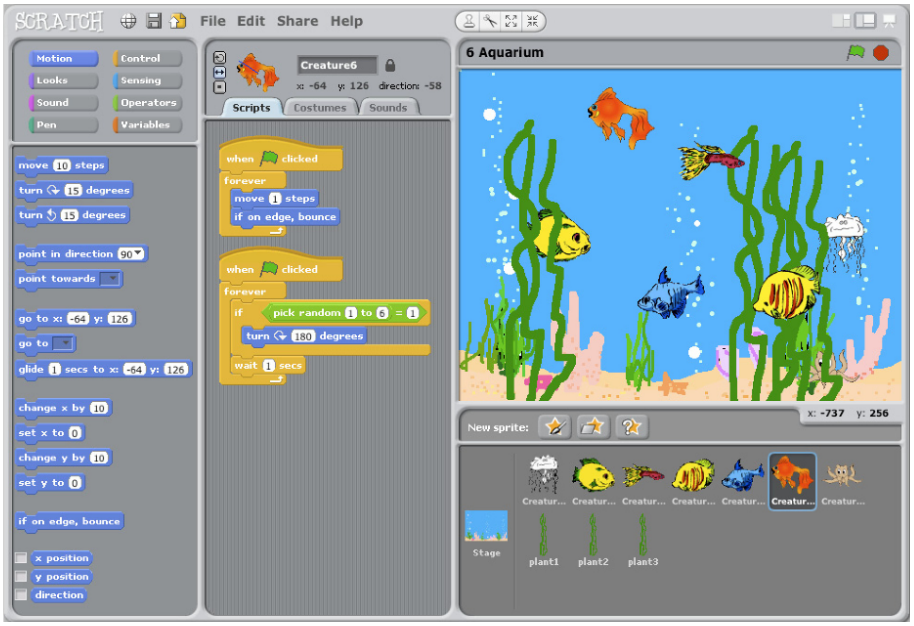


Figure 2.4: The scratch user interface (Maloney et al., 2010)

Sonification Sandbox was developed in the study of Walker and Cothran (2003). It was continued by Davison and Walker (2007) and improved on several features and added some new ones as well. It is a graphical toolkit that allows users to map several data sets to timbre, pitch, volume, and pan, with full control over the default, minimum, maximum, and polarity for each attribute. Figure 2.5 shows a sample interface of the mapping panel and Figure 2.6 shows how the data are graphed. It emulates the sandboxes in playgrounds by making it compatible to all, creating a sandbox that fits all.

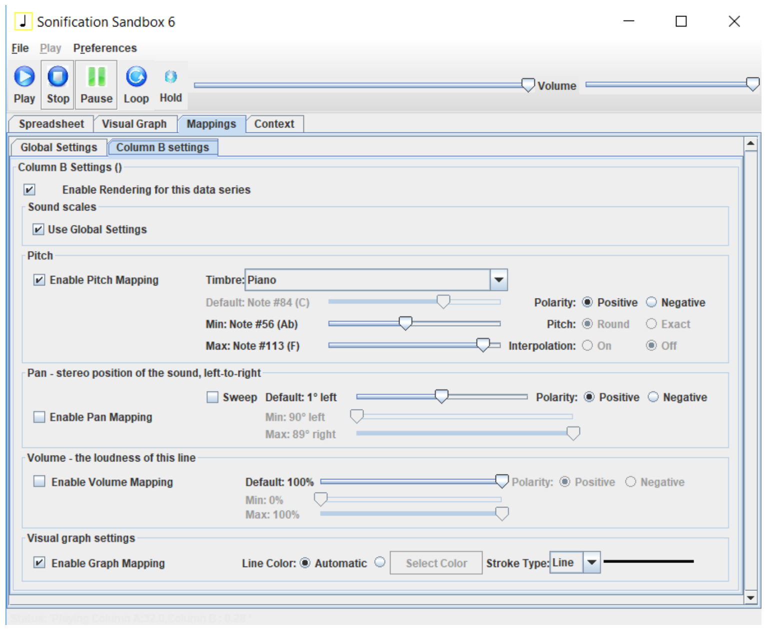


Figure 2.5: The mappings panel for the sonification sandbox (Walker & Cothran, 2003)

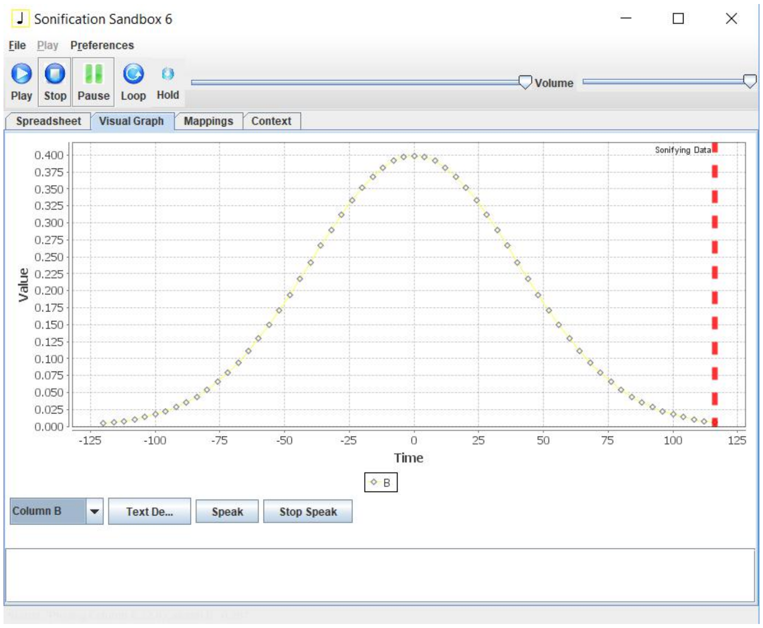


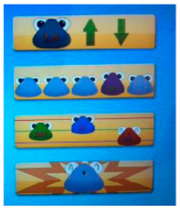
Figure 2.6: The visual graph panel for the sonification sandbox (Walker & Cothran, 2003)

The study of Paule-Ruiz et al. (2017) developed and evaluated SAMI (Software for music learning in early childhood education). SAMI is a mobile application designed to aid children learning music. The study evaluated SAMI by separating the children into two groups. The control group used Montessori bells, while the experimental group used SAMI. The experimental group was divided into groups of five and invited to use a tablet in a quiet room outside the classroom with child-sized tables and chairs. The children used SAMI over five sessions divided weekly. Data collection was carried out in four phases. The experiment allotted one session for the children to get familiar with SAMI. The children would have to observe how the mascot moves and sings to each note. The children were then asked questions and, when answered correctly, the child gets a reward. The second phase observed the children's development of sound discrimination. Phase 3 conducted interviews with the children which was done after three weeks after phase 2. The authors used a semi-structured format asking them which was their favourite game, the one they liked the least and their perception of learning as seen in Figure 2.7. In the end, surveys and interviews with children show evidence on the positive effect of technology on childrens motivation and interest for the SAMI group.

NAME:

COURSE:

Which is the game you like the most?



Which is the game you like the least?

Have you learnt anything?

TO COMPOSE MUSIC

TO CATCH SAMI

TO MOVE SAMI UP AND DOWN

MUSICAL NOTES

TO SING WITH SAMI

NO/I DON'T KNOW

Figure 2.7: Children's questionnaire (Paule-Ruiz et al., 2017)

In the study conducted by Zhou et al. (2011), the authors developed and tested MOGCLASS. MOGCLASS is a multimodal collaborative music environment. By using MOGCLASS, teachers are able to manage the classroom better and lets students have a better musical learning environment. In the experiment for MOGCLASS, the music teacher is given a lesson plan which starts with the introduction of the instrument by showing students how to play some notes. Next, the students are asked to answer Q2-Q5 in the questionnaire as seen in table 2.2. Afterwards, The student are taught how to play a simple song where the students can make use scaffolding feature. The scaffolding is used to guide people through the usage of devices with the use of visual hints similar to karaoke. After learning a simple song they are taught an advanced song. Here, the students can still use the scaffolding. The students are then asked to answer Q1 - Q7 of the questionnaire (table 2.2). In the final lesson, students are asked to try to perform the advanced song on their own without the use of the scaffolding. After this lesson, the teacher will grade and assess the students in terms of creativity, style and technical proficiency. Lastly, the students are asked to answer the questionnaire once more.

#	Questions
Perceived Enjoyment	
Q1	I enjoyed the music lesson.
Perceived Competence	
Q2	I feel the instrument is easy to learn.
Q3	I can easily play music using the instrument.
Perceived Autonomy	
Q4	I would like to use the instrument frequently.
Q5	I would like to play more songs on this instrument.
Perceived Relatedness	
Q6	I enjoyed the music that our group performed in the class.
Q7	I am happy with my performance in our group.

Table 2.2: MOGCLASS questionnaire (Zhou et al., 2011)

Xylotism is an interactive game implemented in a sandbox environment that aims to help children learn and teach music to children (Elahi et al., 2017). The study tried to mirror the scenario introduced in the study of Taheri et al. (2016) where the children trying to learn music is accompanied by a robot and xylophone (Taheri et al., 2016). At the beginning of testing Xylotism, the game's instructions are first described to the child. Then, half of the children were tasked to use the application, while the other half were tasked to use a real xylophone that resembles the application. After 8-12 minutes of playing, the children using the application then switched to using the xylophone, and vice versa. After these, a scenario performed previously by Nima robot (Taheri et al., 2016) is simulated, where the instructor plays a rhythm and the child tries his/her best to imitate the instructor. The instructor encourages or warns about the right or wrong answers, respectively. They then used Stambaks Rhythmic Structures Reproduction test, a test containing 21 easy to hard rhythmic tasks that will assess the participant by having him/her reproduce the pattern after hearing by tapping (Gardner, 1971), in order to gauge how much the child learned.

Table 2.3: Related studies on sandbox environments and other dynamic interfaces

Authors	Focus	Theory/Principle	Contributions/Details
Prevelakis & Spinellis (2001); Goldberg et al. (1996)	Sandbox Environment	Sandbox environments allow users to interact with it boundlessly.	A sandbox approach is implemented by executing a software in a specific operating system environment. This allows users to interact with it boundlessly.
Marting et al. (1999); Inal & Cagiltay (2007); Burton & Pearsall (2016)	Children's use of sandboxes	Children prefer playing games, in the outside world.	Children playing games helps them think creatively. Being able to play without worry stimulates their minds. Using apps allow them to emulate this.
Walker, Cothran (2003); Davidson & Walker (2007)	Sonification in sandbox environment	Sonification	Sonification Sandbox is able to map several data sets to timbre, pitch, volume, and pan, with full control over each attribute.
Maloney et al. (2010); Ouahbi et al. (2015); Erol & Kurt (2017)	Scratch and its sandbox environment	Benefits of Sandbox approach	Scratch is able to help novice learners learn programming concepts with the use of a sandbox environment.
Paule-Ruiz et al. (2017)	Testing SAMI to children	Children should be interviewed and surveyed during, and after using the application	In-depth process on testing a mobile application to children.
Zhou et al. (2011)	Testing MOGCLASS to children	Asking children to answer questionnaire should be step-by-step	Children are first shown how to play some notes. They are then asked some of the questions from the questionnaire. After being able to perform simple songs, they are again asked some questions. The children are then asked to answer all the questions.
Elahi et al. (2017); Taheri et al. (2016);	Testing Xylotism to children	Children learn better when there is an instructor they should follow	Children are first shown how to use the application, after which they are asked to imitate the rhythm made by their instructor. They are then assessed by using 21 easy to hard rhythmic tasks.

2.3 Review of Related Software

There are several music applications that are not sandbox in approach but still provide virtual collaborative environments for expression and composition. One example is the work of (Zhou et al., 2011) called MOGCLASS. MOGCLASS is a multimodal collaborative music environment that enhances students musical experience and improves teachers management of the classroom. This application features an interface for the teacher and a separate interface for the students. The teachers interface has features that allow the teacher to manage the class better, while the students interface has features that mimic instruments this supports a music technique called scaffolding.

MOGCLASS simulates three instruments for the students and can be seen in three different student interfaces. The first instrument is called a hitter and it stimulates a drum. It uses an accelerometer in which makes the device detects handshakes and makes a sound proportional to the level of shaking. The second instrument is called a tapper which stimulates a piano. Figure 2.8 also shows how the scaffolding looks like as it is a set of bars that drop down from the top of the screen. The location of the bar shows which note to be played and the size of the bar shows how long the note should be played. The last instrument is the slider and it stimulates a violin. The vertical position of the finger plays different notes on the slider. Figure 2.8 shows the sample student interface of the second instrument which represents the piano.

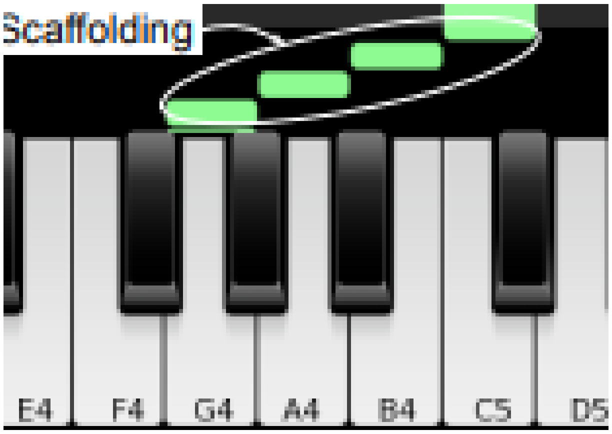


Figure 2.8: MOGCLASS student interface (Zhou et al., 2011)

As for the teachers interface which is shown in figure 2.9, it comes with many features that can help manage the class. The teacher can control which instrument the students interface will display and which notes it can start with. The teacher can also control if the student is muted or not. Finally, the teacher can choose which song will be used when scaffolding is used in the students interface.

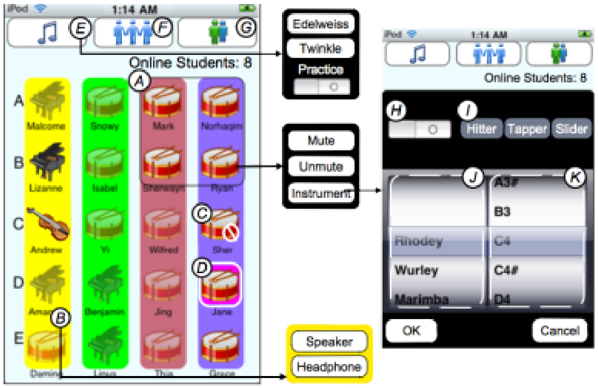


Figure 2.9: MOGCLASS teacher interface (Zhou et al., 2011)

From this application, FireflyX can make use of the scaffolding feature in order to help guide children in learning musical elements. Having a separate teacher and student interface may also be taken into consideration since teachers may help accelerate the learning of the children as well.

Aside from MOGCLASS, more scaffolding can be found in a study by Jørgensen et al. (2015). This includes virtual instruments for children so that they may engage more in museum setups. The application has three instruments to use being the harpsichord, double bass, and the viola. The application suggests using them one by one and in the end all past performances are played back simultaneously revealing that playing instruments together make a composition. All the instruments have colored rectangles that scroll downwards which depicts the note they should be playing. These rectangles are a form of scaffolding.

For the harpsichord, the colored rectangles are above a keyboard, and the rectangles determine which key should be pressed for the correct note to be played. For the double bass, there are colored strings below and the colored rectangles refer to which string has to be plucked in order to play the correct note. The viola, is similar to the double bass but instead of plucking, children have to swipe on the correct string in order to stimulate using a bow and to play the correct note. FireflyX might be able to use the different forms of scaffolding presented here. We can also make use of the way this application simultaneously plays different instruments at once for when there are multiple fireflies created.

The development of musical tools have migrated to mobile environments as well. One study is SAMI by Paule-Ruiz et al. (2017). SAMI is a music learning application for children using tablet-computers. For it to be able to teach music, it has four games that are designed to facilitate learning and encourage children's thinking and creativity. SAMI, a triangular blob with large eyes, is also the mascot of the game and is interacted with in all of the games. The first game aims to educate the children by using the ears to identify several sounds. In short, the first game is a memory game using notes. The game plays a note and the task of the user is to tap SAMI with a similar noise representing that note. Each SAMI has a color at first to determine the note. The second game is a memory game with order of the notes wherein the children have to tap on SAMIs in the correct order. This aims to teach notes as if they were part of a major chord. The third game is a reactive tapping game and aims to teach fine motor skills required to play instruments. There are three rows and each location of SAMI places a different note. SAMIs appear and the child needs to tap on SAMI before they disappear. SAMIs on the top row play higher pitched notes when tapped. The last game is a composition game which combines all the previous games and has the child try to compose with SAMIs by having arrange SAMIs in different heights and at a certain arrangement. These games may serve as an inspiration for how some features or parts of FireflyX may be able to be implemented.

Just as SAMI teaches with its games, an application by Elahi et al. (2017) also teaches with instructions. This application features a bot named Nima that gives instructions. The instructions given by Nima follow a step by step process. The initial stages would be instructions to get the user to understand notes. These instructions include commands for the user to do something or questions to ask the user. The later stages would involve trying to make the user replicate rhythms.

Based on the user's actions, Nima also gives some feedback to help guide the user. When the user is doing well, Nima can respond by doing dances and saying things like that's great, bravo, etc. If the user makes a mistake, Nima says things like pay attention or try again. Aside from these responses, there are also emojis showing happy faces or sad faces depending on the user's actions as well. From this application, FireflyX may be able to use the instructions and feedback system given by Nima. The instruction system may help guide the children on the usage of FireflyX. The feedback system may encourage the children with their usage of FireflyX.

Aside from Xylotism, there are other musical applications where childrens preferences are considered especially in measuring engagement or fun. One study is by Burton and Pearsall (2016). Common application preferences by children include easy to navigate menus, a variety of ways to engage, visual stimulation, famil-

Table 2.4: Child friendly features checklist (Burton & Pearsall, 2016)

Application	Characters	Movement	Dancing	Animation	Children	Songs
Juno's Piano		✓	✓	✓		
Virtuoso Piano						
Monkey Drum	✓	✓	✓	✓		
Percussive						
Toca Band	✓	✓	✓	✓	✓	
Loopseque				✓		
Ambient Mood	✓	✓		✓		
Bloom HD						
Kids Song Collection	✓	✓		✓	✓	✓
iTunes Collection					✓	✓
Lily Rock Band	✓	✓	✓	✓	✓	✓
Rockmate						

iar musical material, music that continues without manipulation, and animated characters such as animals, babies, children, movement, and/or dancing.

A table in the study as seen in Table 2.4 shows different applications wherein the applications in bold are considered the child friendly applications while the italicized ones arent. The table also shows if the application has features that children like. The less child friendly apps are similar to the child friendly application above it in regards on what it aims to teach.

The first two apps for example aim to teach melody according to the study. The first application, Junos Piano is treated by the study as the child friendly application due to it having the features normally preferred by children as seen in the table. In Figure 2.10, the application has bright colors and a cute character on top of the piano.

Figure 2.10: iPad kid friendly example (Burton & Pearsall, 2016)

However, Virtuoso Piano is missing these preferences thus making the study treat it as the less child friendly application. In figure 2.11, the application is missing characters and only has some dull colors to it.

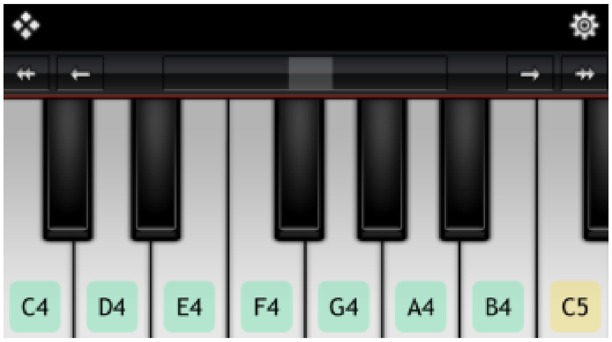


Figure 2.11: iPad not kid friendly example (Burton & Pearsall, 2016)

In order for children to use FireflyX longer, FireflyX will use some features, which will be tested through the different iterations, that children find appealing as seen from the child friendly applications and try to avoid missing some features such as the less child friendly applications.

Not all applications may be usable for all children however. Some children such as the ones diagnosed with autism spectrum disorders may be in need of social skills so that they may be able to live independently when they reach adulthood. A study by Hourcade, Bullock-Rest, and Hansen (2012), includes the creation of applications in order to promote social skills to these children. One of the applications created was a music authoring application.

The application has a harp like screen and the children are able to choose tiles which determine what note they would play, the notes on the higher part of the screen depicting higher notes and vice versa. The notes are played in sequence, with the note that is currently played turning green. Since this application aims to promote social skills as well, the music authoring application was designed to be used by multiple children. The multi-touch feature where it can have multiple notes selected at once makes it possible for children to edit at once.

Since the study also shows that the children mentioned using the application makes it more enjoyable. FireflyX may be able to incorporate the collaborative multi touch feature this application presents as it may attend to more than one children at once so that FireflyX maybe more enjoyable for children.

Table 2.5: Related systems for children music learning tools

Authors	Name of System	Platform	Comments/Findings
Percival et al. (2011); Jorgensen et al. (2015)	MOGCLASS; A Mobile Music Museum Experience for Children	Ipod Touch; Tablet	Both show basic scaffolding for various instruments.The first system features a separate teacher and student interface. The second combines music played and plays it back to the user.
Burton & Pearsall (2016)	NA	Ipad	It differentiates popular kid-friendly applications and less kid-friendly applications using common preferences by kids in applications.
Álvarez-García et al. (2016); Ahmadi et al. (2017)	SAMI; Xylotism	Tablet	Both systems have integrated learning music in a step by step process by using games. They both use child friendly graphics and motivation for the child as they learn musical concepts.
Bullock-Rest, Hansen, & Hourcade(2011)	Music Authoring Application	Tablet	Focusses on an application made for social interaction. The application aims for children to make music together on a harp like screen.

Chapter 3

Theoretical Framework

This chapter provides a clear discussion of different studies and theories behind each concept of the study. The first section will discuss the theories on Human-Computer Interaction, Interaction Design, and also Evaluation methods on User Experience, while the last section will focus on Musical Representation. These will be accompanied on the other hand with theories on how children go about in these respective ideas.

3.1 Interaction Design

Interaction design as described by Preece, Rogers, and Sharp (2015) is “designing interactive products to support people in their everyday and working lives”, that helps in creating a user experience that enables the users in their work and interaction with others. People use interactive objects everyday like phones, machines, etc., but not all of these are easy to use or effortless. Interaction design focuses not only about giving people a product but also how it understands how a particular feature can affect how people work as well as how it can improve their experience (Dix, 2009; Preece et al., 2015).

The aim of interaction design is to integrate usability in designing the system, that makes a product that is easy, effective, and enjoyable to use for the user (Preece et al., 2015). User satisfaction is of vital importance in interaction design.The further study of interaction design have led to experts creating processes and identify a group of design principles. These principles will serve as a help in creating good interfaces for users (Preece et al., 2015).

The use of interaction design will be integrated in the different iterations of designing the application. This theory will be important in identifying the principles that will serve as our guidelines in designing the interactions in the interface.

3.1.1 Human-Computer Interaction

Human-Computer Interaction or also known as (HCI) studies ways on how many different computer technologies affect human activities (Dix, 2009) and how it enhances the quality of interaction between humans and the computer (Baecker, 2014). Research in this field has been an integral part in the development of early systems, like the graphical interface of Windows 95 and another is that it has greatly improved the World-Wide Web (Myers, 1998). Both these early systems show how HCI research has greatly improved the usability of their system and how further interface improvements has enabled more research to be done on this field.

Kaptelinin characterized the subject Human-Computer Interaction in three dimensions as seen in Figure 3.1. The first is the interaction between the user and the environment which transcends the user interface, it explains how the interaction with computers help people in achieving their goals. Next is development, and the researcher describes this as the user develops from being a novice to often becoming an expert. Last is the individual/social dimension as the researcher characterized the word "user" not only as an individual but also as a group or an organization.

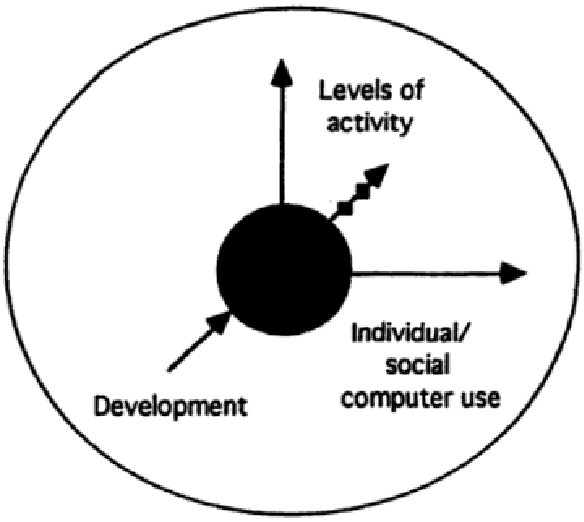


Figure 3.1: HCI three-dimensions (Kaptelinin, 1996)

According to Dix, Finlay, Abowd, and Beale (2004), one of the core topics of studying HCI is the usability of these technologies. Usability according to Frøkjær, Hertzum, and Hornbæk (2000) is described as taking into three different aspects such as satisfaction, efficiency, and effectiveness. Satisfaction takes into account the use of the system and how comfortable they are with it Frøkjær et al. (2000). Also described by Frøkjær et al. (2000), user satisfaction is described as the preferences of the user on the usage of the application on the tasks given to them. Efficiency talks about the relation between users completing the tasks and the resources used to do it (Frøkjær et al., 2000). Lastly, effectiveness shows how users properly do their tasks and also achieve certain goals in using the system as determined by some indicators of efficiency for example the completion time of tasks and learning time (Frøkjær et al., 2000).

The increase of research in this field as well as the emergence of better technologies has led to the creation of new topics under Human-Computer Interaction like studies on interaction design and user experience.

3.1.2 Mobile Interaction Design

Interaction Design can also be applied to mobile applications like smartphones and tablets. The change of integrating an application to a mobile platform presents unique challenges in making the interaction. According to Tidwell (2010), these challenges can be summarized into five categories. (see Table 3.1).

Table 3.1: Challenges of mobile design

Challenge	**Description**
Tiny Screen Sizes	In mobile devices space for information is limited. Unlike in computers where there are long header menus, in desiigning a mobile application all the excess assets should be removed (Tidwell, 2010).
Variable Screen Widths	The second challenge presents the difficulty in making a design that would scale well on different screen sizes (Tidwell, 2010).
Difficultly of Typing	Users do not like it when there is a need to type large amounts of ext with the keypad (Tidwell, 2010).
Challenging Physical Environments	Lastly, people use their mobile devices in different places. Places where it could be really bright or dark, during transportation, in bed, etc.(Tidwell, 2010).

For our application the other problems are not to be tackled as much, as firstly the problem on variable screen widths is as not a problem since we will only focus the iPad. Second, the difficultly of typing is not much of a problem since the user will not type a huge amount of text. Third, the environment where the child will use this is not a problem since the place will mostly be indoors. For the application, we will mainly focus on the problems of tiny screen sizes and touch screens seen in Table 3.1. The problem of tiny screen sizes in our application is that the size of the iPad screen would be limited as we would also have to properly put the assets on the screen to minimize this. Lastly, the problem on touch screens is what this study aims to solve as we would use gestures aimed to help the interaction between the interface and the user's fingers.

3.1.3 Design Principles

These principles are used in solving the challenges provided in designing the interaction for the users. Blair-Early and Zender (2008) described design principles as "clear rules of thumb" that also consist of defined features, Kimball (2013) also described that these principles are heuristic methods that help in making decisions. Norman (1999) also states that a successful design comes with a set of underlying principles.

In making systems developers and companies often think that they should only focus on enhancing the aesthetic appearance of their product in itself rather than also putting equal importance with the overall experience and usability of them (Norman, 1999; Bläsing, Batyuk, Schmidt, Camtepe, & Albayrak, 2010; Stephanidis, 2012). Having a clear idea of the goal of the software from the start is very important, as the interface can be made to achieve the goal that was set and the design should highlight what the goal is (Blair-Early & Zender, 2008). The overall goal is to design a product that is pleasing to the user for both viewing and using.

Williams (2015) and Stephanidis (2012) both state four key principles to acknowledge in designing interfaces for different kinds of platforms. The first is *contrast*, this makes the use of shapes, colors, and sizes to draw the users attention. Following this makes it easy for the users to distinguish where they need to focus on. Second, is *repetition*, it talks about having a consistent visual scheme that it makes it easier for the users to recognize. The use of same text, colors, and fonts helps in unifying the design. The third is *alignment*, and this principle talks about the placement of the design elements through out each screen in the system. This principle brings order to each screen and makes the design much more uniform to one another. Last is *proximity*, this principle brings related design elements to be grouped together to show how each element is connected and helps in focusing the users attention.

Other important principles on the other hand are suggested by Blair-Early and Zender (2008), one of them is the principle of an Obvious Starting point. This principle can also be used because the user needs to know how to start interacting with the system. The starting point can serve as the point where the user learns more about the interface from the first encounter and cognitively finding patterns helps in the learning. Another is a Clear Reverse and this principle explains how the user can obviously see the way to reverse a particular action or exit the session. Knowing a way to reverse an action or having a clear exit route may give users a sense of confidence in using the system as they need to experience that they can experiment with the system without damaging it.

Mobile interfaces have there own limitations when compared to the normal setting of desktop interfaces (Gong, Tarasewich, et al., 2004). Due to these limitations design principles that are used for desktop interfaces have been modified to aid in creation of mobile interfaces (Gong et al., 2004). Nilsson (2009) suggests guidelines that help in answering some common issues in mobile interfaces found in Table 3.1.

For the problem of screen space an issue identified was the issue of horizontal scrolling this is due to the fact that information on the screen is usually more connected to ones in the same line rather than the ones in different lines (Nilsson, 2009). The principle provided to answer this issue is for the attributes on the screen is to be optimized in terms of size and sequence. Changing the layout can help in avoiding the need of horizontal scrolling, an example is changing the screen orientation if the user is given an option to change between landscape and portrait or only given one of the two (Nilsson, 2009). Another problem is in typing text, as the keyboard that is provided is usually small for the users that it is hard for the fingers to enter (Nilsson, 2009). An approach to answer this problem is to provide auto complete of text by trying to predict the word the user is typing by giving suggestions near the current type letters. The last problem is in touch screens, as not all mobile devices are given a stylus that helps with the users interaction with the device. A principle to help solve this issue is to make the menu choices finger friendly, since the problem lies on the fingers not always hitting the small details of the screen. This helps in making interaction mechanisms like lists, buttons, menus, etc. finger friendly which helps the use in having more control in the application (Nilsson, 2009).

Though the principles presented are not solid rules, nonetheless these principles can still be heavily considered in being followed when designing an interface. The principles mentioned in this subsection was used as a guide in designing the interface. The four key principles will be taken into consideration in the designing of the assets in the sandbox environment and also in the flow of the usage of the application. We will use the principle of the obvious starting point so that the child will have a screen that they can go back when they are lost. For the clear reverse this is very helpful as the child will make mistakes in using the sandbox and this is helpful so that these mistakes are reversed to let the child finish their tasks.

3.1.4 Gestural Interaction

The goal of Human Computer Interaction is for humans to naturally interact with technologies like computers for their everyday use (Hasan & Kareem, 2012; Rautaray & Agrawal, 2015). For a long time gestures have been considered as a bridge for the humans to interact with these computers, because of the popularity in the usage of hand-held touch screen devices like smart phones and tablets (Ruiz, Li, & Lank, 2011; Hasan & Kareem, 2012).

According to a study by Roth (2001), gestures can be characterized into four. First is *Rest* that actions begin from the point of rest, then it moves away to another position and eventually return to the point of rest. Second characteristic is *Peak or Stroke*, which shows the moment of the gesture which denotes movement. The third is the *Preparation and Recovery Phase*, is when the hand goes back to the resting position. Last is that usually gestures are *Symmetrical*.

There are many user interfaces that gestural interactions have been considered very natural, yet others are harder to understand at first like the multi-touch gestures for devices like tablets compared to other gestures where it can be easily be learned by the user (Mortensen, 2019). An example for mobile device users is the simple gesture of swiping left or right compared to a more complex gesture like a multi-finger swipe in a certain direction (Mortensen, 2019).

Touch gestures have been seen as an intuitive way of communication between the user and the computer, the actions that build up specific functions makes it natural to use (Rautaray & Agrawal, 2015). In a research done by Chan, Deja, Tobias, Gonzales, and Dancel (2019) tasks were made possible with the use of gestures. In integrating the gestures for their mobile musical composition tool they recommended five gestures that can be used for similar tasks, these gestures are Tap, Tap & Hold, 1-Finger drag, 2-Finger drag and Pinch. In the different iterations of their research they were able to map the appropriate gestures to accommodate the tasks needed for their composition tool.

There are many gestures for mobile applications that use a touch screen. Common gestures include tapping, flicking, sliding, dragging & dropping, rotating, pinching and spreading (Aziz, 2013). Generally younger children that are below age 4 may have a hard time with some gestures due to not being familiar with them. Children above age 4 however know how to use all these gestures. Specifically children aged 7-12, have no problem using these gestures to deal with 2D or

3D objects. They do not even have problems doing different gestures in a single application or interface. However they seem to prefer apps that focus on tapping. These children as well prefer more fun and more challenging applications to keep their attention.

For the gestures of the application we will be following the research of Chan et al. (2019) as they already provided specific gestures that can be used in a musical application. In the integration of these gestures we would be focusing on how each gesture will help the user in completing their tasks. The specific gestures we would will be focused on the Tap, Tap & Hold and 1-finger drag. For the Tap this gesture will be mostly used in the buttons. The Tap Hold will be used as a preview of the parts of the firefly model. Lastly the 1-finger drag will be mostly used on assets regarding adjustments and scrolling.

3.1.5 Gestalt Principles

The set of Gestalt Principles comes from psychology, where it says how the human brain will simplify things like elements and recognizing patterns. The Gestalt principles provide six fundamental laws that designers can follow (Yee, 2002; Chapman, 2018).

1. Figure/ground
2. Similarity
3. Emergence
4. Closure
5. Continuation
6. Symmetry and Order

Figure/ground explains the distinction of the object with relation to the foreground and background of the design.The important thing in this law is how it contrasts and how the object is still visible and understood.

Similarity says that humans usually see the same things like size, color, or shape in the design of elements and they tend to group them together. The main use of similarity is to bind elements together that are not necessarily next to each other in the design.

Emergence shows how elements that are in range of each other can be grouped together while others also near one another are grouped separately.

Closure explains how humans want to see complete objects so if they don't they visually connect missing information through familiarity and patterns seen.

Continuation talks about how the human eye will most likely follow a smooth path and it would want to see a clear flow of these visual elements.

Symmetry and Order takes into consideration how the design is complete and balanced, because if not time and effort will be exerted by the user in trying to understand it.

The gestalt principles will be used in the application to help design the different parts of the screen. All of these will be taken into consideration but some would be used more, as some assets need these specific principles to be displayed much clearer. In designing the objects in the interface the figure/ground principle helps us in distinguishing these objects from the background so it can be clearly seen by the child. We will use the Similarity principle in designing assets in screen as our target users which are children need to identify visual patterns to be able to complete their tasks. The principle of Emergence will be used in grouping similar assets together to make it easier for the child to identify their functionality. Lastly Symmetry and Order helps us in making the application much more balanced to help the child immediately understand the functionality of the system.

3.2 Understanding Children Interaction

As HCI maybe generally for understanding general humans, we need to focus on children as they have aspects adults do not have. These aspects can result in them having different needs compared to usual adults to where HCI is generally designed for.

3.2.1 CHI Techniques Enabled Through Play

CHI Play is a yearly conference that focuses on topics across all areas of play, games and human-computer interaction. They feature papers that show different techniques and practices for games. Some of these are specifically studies are aimed towards children and we can use them for designing our application.

A study by Gray, Campbell, Cater, Bevan, and Gilchrist (2018) analyzes five commercially available applications for preschool children. They discuss what factors in these applications may lead to children liking or disliking the application. They discuss the importance of characters, support for competence, interaction complexities, and the understanding of buttons and menus. Different game characters with different personalities may increase the chances of a child liking a character which would contribute to the game's enjoyment. Support for competence involves a child getting in-game rewards for doing good in the game. This may increase enjoyment as the children enjoy sharing their achievements however giving the child negative feedback upon doing badly in a game lessens enjoyment as well. Interaction complexities described that confusing tutorials such as one where actual game play cannot be differentiated from a tutorial makes it confusing for the child. This makes them think they were doing things right but it was just the tutorial auto playing for them leading them to perform badly when it came to the actual game. Understanding buttons and menus talk about the difficulty of children have with complex menus and how they ignore text based interaction.

They also seem to not understand some symbols and colors of the buttons but can find out what they do with game play.

A study by Scheepmaker, Frauenberger, and Spiel (2018) discusses that play has a different definition for children as it does for adults. For adults it is generally any enjoyable activity however for children it is something they want to and get to do. Specifically, the children are in control meaning they started playing because they want to. This means they play for them includes things that they do not need to finish or seek approval. An important aspect of play is called appropriation. Playful appropriation is a transformation of situations or elements into fun experiences. An example seen in the paper involved an animal like robot designed to bring out certain behaviors in children. The different children had different abilities and experiences therefor leading to them having different ways to appropriate the robot into their own versions of play. This leads to the idea of designing applications for appropriation. These designs are defined to be ambiguous,in need of a user who will complete them and break away from a usual designer-centered thinking where the system makes it clear how the system should be interacted with.

A study by Li (2018) shows talks about playfulness. In general, it is a mindset where something is approached without seriousness or a clear goal. Playfulness may help in making products go beyond their initial level of entertainment. An idea for interaction for a play setting is described by Crowell, Mora-Guiard, and Pares (2018). This idea discusses interaction for play is a three stage model. The three stages are invitation, exploration and immersion. Invitation is the state where the system should invite the user to engage with it. Exploration is when the user is trying out different possibilities with the system. Finally immersion happens when the user has explored enough with the system and is creating different things that applies everything learned in the exploration stage.

FireflyX would be able to use support for competence in order to motivate the children in the first paper by Gray et al. (2018). This can be seen at the very least in the tutorial when the children is congratulated for completing it. It would be also be able to use interaction complexities for its tutorial and use understanding of buttons and menus for the design of the user interface. This can be used specifically used by making objects that can be interacted appear differently from objects that cannot be interacted with. For the second paper by Scheepmaker et al. (2018), FireflyX can use definition of play and try not to use the usual design centered thinking in its design. By this, we will design FireflyX in a way that children will discover different ways how to use an application and the application will not have a single way to use it. In the last works by Li (2018) and Crowell et al. (2018), FireflyX can use these three stages in its design and work around it. For the first stage, we can invite children to interact with objects with obvious signs such as glowing and moving objects. In the second stage, the application must be designed in a way that a child can explore the different possibilities of its uses without being limited. This can be helped done by having a minimum tutorial to show the bare minimum of what a child needs to know in order to use the application. Another way to apply this is also not having objectives or just having a few that so that the child's mentality does not focus on achieving them and are free to do whatever they want.

3.2.2 Theories on Children's Cognitive Development

Aside from papers from the CHI PLAY conferences, there are also general theories associated with children's cognitive development. Due to how children today are reported to have an increased used on computers, it is important to take into account the children's interests, abilities and developmental needs in the design of these technologies (Hourcade et al., 2008).

In order to maximize the learning of the children, existing research on child development must be considered. Jean Piaget, one of the most influential experts on child development, has views on children that have affected the field of computer child interaction. Three of his works are to be considered for computer child interaction. The first work talks about how children construct knowledge. The second work talks about the factors that affect development and finally the last work talks about the different developmental stages children go through (Hourcade, 2015).

Piaget observes that learning occurs during a process of adaptation. When children are undergoing adaptation, they are creating their own knowledge when they are experiencing and interacting with the world. However the idea that children make their own new knowledge from their experiences and their own current existing knowledge is called constructivism. However, Seymour Papert a Key figure in child computer interaction expands on Piaget's ideas and proposes constructionism. This proposal talks about how adaption works best when children are making something to share with others. This emphasizes on providing children technologies where they get to be creators. This proposal puts an emphasis on social and motivational aspects of learning as well as providing children more opportunities to alter modify their environment.

Piaget discusses that there are four aspects that affect development. These are maturation, experience, social aspects and emotions. Children's physical maturation limits their learning. The limited cognitive and motor abilities of children affected by their maturation would limit their interaction with technology. On the other hand, experience is a important factor for adaptation as it is required in the building of knowledge. This puts emphasis on experiencing the world rather than being told by it. These unique experiences can be be provided or augmented with technologies using virtual environments or simulations. Social aspects such as social interaction play a key role in development such as when children copy the way of how experienced adults complete think and complete tasks. Technologies can help in this field by linking ideas and interests for children and the experienced adults. With the thought of emotions comes motivation. Motivation affects development since it deals with the children's drive to grow. It can be achieved by making learning relevant to children's lives and interests. Papers expands upon this by believing that learning activities with topics that children are passionate about will motivate learning better. This highlights the need for flexible learning activities that answer to every child's interests. This is where computers can shine due to their ability to provide a variety of learning activities and opportunities.

Commonly used software to provide a variety of learning today are games.

Piaget proposes four stages of development: the sensory-motor stage, pre-operational stage, the concrete operations stage, and the formal operations stage. We will only discuss the pre-operational stage and the concrete operations stage because that is where our target audience lies. Children ages 2 to 7 are included in the pre-operational stage and are focused on seeing the world on their own perspective. This makes them usually focus on one object at a time which limits understanding navigation through hierarchies. The concrete operations stage include children age 7 to 11. These children are more likely to appreciate another one's perspective making them suitable as design partners with adults for making applications. Due to this, they are also able to understand hierarchies and are compatible with more types of technology.

Another theory for cognitive development are the information processing theories. These theories treat the brain as a computer that manipulates information. Cognitive task output is affected by changes in the information in the mind and mental hardware as the brain develops. For children, this often leads to variability in their cognitive tasks, in which children are choosing from an array of strategies and will not stick with the same strategy consistently. As time passes, they may end up preferring the most successful strategy for them though another cause for variability is trying to apply the same strategy towards a variety of tasks having different results in success. Children's variability must be taken into account in usability testing with them.

From these theories, we can use the theories by Piaget in designing FireflyX as it mentions to avoid the use of navigation through hierarchies such as drop down menus and motivating children by making activities relevant to their interests. Other ways we can apply the theory also include by knowing what children have learned and experienced in their schools in our age target, we can know what they are capable of understanding and adapting to. The information processing theory can be used to see if repetition is effective during observing as it mentions variability to which children try different things in doing the same tasks until they are successful. By seeing a child try different things in different attempts to achieve the same thing, we can say that repetition of the same task for learning is useful. As also mentioned by Piaget, trying out new ways to achieve something may also be form of adapting which enforces repetition as kind of a form of forcing adaptation on the child.

3.2.3 Standards in Children Interaction Design

To help with interaction, standards on how to design applications for children have been made. A study by (Markopoulos & Bekker, 2003) mentions that there are two major areas where designs should focus on. These areas are age specific interaction styles and the involvement of children in the design process. Age specific interaction styles include different interface related design such fonts, menu structures, on-screen object sizes, etc. The involvement of children in the design process can be showed in (to be added figure). In this figure, the relation of technology to children can start from children being end-users to children being designers. Moving from within the figure to the other layers to figure, children can become more active and responsible as well as being more involved in the design process.

However, the activities children do with technology are mostly limited to either education or play. Studies have explored the relationship between education and play (Markopoulos & Bekker, 2003). These studies show that fun contributes as motivation for doing activities so utilizing it can make learning more effective. Playful learning is described to have five core elements. These elements are exploration through interaction; engagement; reflection; imagination, creativity, and thinking at different levels of abstraction and; collaboration.

Child computer interaction (CCI) is a relatively new research area which is defined with the same idea as a HCI but for children instead of humans in general (J. C. Read & Bekker, 2011). The necessity for CCI was associated with three main differences between children and adults with the use of computers which are activities, behavior and concern. Children do different activities with computers, behave differently around computers and have different concerns for computers when generally compared to adults. CCI has established provided 10 guidelines on how and what to design technology for children known as the 10 pillars of CCI (Hourcade, 2015).

1. Work in interdisciplinary teams
2. Deeply engage with stakeholders
3. Evaluate impact over time
4. Design the ecology, not just the technology
5. Make it practical for childrens reality
6. Personalize
7. Be mindful of skill hierarchies
8. Support creativity
9. Augment human connections
10. Enable open-ended, physical play

Work in interdisciplinary teams talks about how teams should be composed of people experience in design and evaluation methods for the technology builders (computer scientists, etc) and experts at the target children population (teachers, parents, etc.). Optionally a team may also have a designer and a expert on the topic where the technology covers (librarian for library software).

Deeply engage with stakeholders talks about how every different generation of children has their own view, expectations, and experience with technology. As adults have difficulty remembering what it takes to be a children, they have to involve children in the design process in order to improve the chances of successfully making a child-centered design. Even adults that children interact with are also affected by these technologies so they also must have a role in the design process. If the design team isn't familiar with the stakeholders, they should interact with them more.

Evaluate impact over time shows that children do not instantly change as they use technology. They must be observed for an extended period of time to evaluate how technology has affected them. These changes include the children learning new abilities and skills.

Design the ecology, not just the technology means the design process should not stop at the technology but must also be used in designing the physical environment. The people present when the technology is used and support activities can also be taken into account for designing the children's ecology when using the technology.

Make it practical for childrens reality includes how designs should consider the context where the children may use the technology and if they are fit for the situations to be used in in order to be successful. Technologies should be relevant to childrens lives, needs, and interests.

Personalize mentions that different children have different experiences, needs, interests, skills and more. Some children even come with specific impairments. With these differences, personalization can provide great benefits in making technology advantageous for children.

Be mindful of skill hierarchies talks about how in many fields, the learning process teachers basic skills before teaching its more complex skills where basic skills are needed.Design teams should take into account the basic skills needed for their interactive technologies. Skill hierarchies where the order of the skills to be learned should be taken note of.

Support creativity takes place if learning is more motivating to the child if it done with a purposeful meaning such as in building. This is an application of the idea comes that from Seymour's idea of constructionism which again talks about how adaption works best when children are making something to share with others.

Augment human connections is when technology doesn't interfere with a child's personal connections with primary caretakers and instead augment them can result in more positive development. Face to face interaction is a critical element in learning some skills such as negotiating, listening, sharing, etc.

Enable open-ended, physical play such as open-ended physical play is when children can play freely and creatively without limit. This can result in positive effects such as the child developing problem solving skills, having better health, learning to engage with peers, etc.

Aside from these pillars ,there are also some basic principles that have been developed by researchers over the years (Hourcade et al., 2008). The important aspects of visual design for the children are the icons, text and the complexity. For humans in general, Icons must be easy to to recognize that it can be interacted, represent what they do properly and are distinguishable from each other. The only difference for children is the size of these icons must be proper for the children. The text has to have minimized usage unless it is an application to teach reading. Finally, the visual complexity of the applications must follow multi-layer strategies. These are strategies where children are presented with a few actions or icons to interact with at first and are presented with more as they progress.

There are three main interaction styles. The first being the usage of direct manipulation. The main ideas that direct manipulation utilize include visibility of objects and actions of interest. The visibility of objects and actions of interest involve making objects have distinct look that shows there are actions that can be done to them.

The actions for the objects must be rapid, reversible, and incremental. The actions must be rapid because children tend to be less patient than adults. If the children do not get quick feedback from the action they are likely to lose interest. If an action cannot be rapid, children must still have some way of knowing the status of an action (such as progress bars), the children must be still able to interact with application in another way during the other action taking place and the children must have an option to cancel the action. Reversibility, meaning actions can be undone, on the other hand, encourages the children to explore while making them remain in control. An action of resulting in a loss of child's creation might lead to frustration and the child losing the desire to use the application anymore. Finally the need for an incremental actions, meaning step by step actions, is required so children can do complex tasks. Without these incremental actions, children may find themselves stuck in a task and unable to progress due to solution being to complex leading to frustration.

Another interaction style is the menu. Children are almost always presented with a menu since even a set of choices can be considered a menu. The problem with menus however comes when choices are not immediately visible such as drop down menus. It is found out that menus that had to be brought up with a were easy to forget especially for children making it confusing for them.

The last interaction style is text based interaction. This becomes a problem when children need to type for them to interact with a computer but do not know how to type yet. Similar to lack of the lack of ability to type is the lack of knowledge to spell. A problem would arise if commands need proper spelling but the child is unable to spell them correctly. These interactions may significantly slow down as the child lacks the ability to do them.

From the pillars, most of them can be used in the design of FireflyX due to its nature of being an educational sandbox for children. Deeply engage with the stakeholders pillars are done first so we understand what we need to create first which is what we get by talking to music experts. Work in interdisciplinary teams is not used because there are no real experts in the field of music in our team but we are discussing with the stakeholders to make up for that. Due to it being a sandbox, the pillars of support creativity and enable open ended play are applied as it is needed for children to explore and create different possibilities with the fireflies.

- Evaluating impact over time
- Making it practical for childrens reality
- Personalization
- Being mindful of skill hierarchies

These need to be done since we are designing specifically for children in order for them to learn music so we must know what their skills and experiences for their age group is in music. Finally, augment human connections and design the ecology, not just the technology may not be used as this application might be standalone and does not need a supervisor and serve as a supplementary way for learning music.

The interaction styles that were mentioned can all also be used in the design of FireflyX to make it more child-friendly except of course the text based interaction as we use visuals. We will use a mix of direct manipulation and menu interaction styles for FireflyX. This is because we use actions that have choices in which each choice would have different feedback for the child. This can be seen in editing parts of the fireflies.

3.3 User Experience Design & Evaluation

User Experience talks about making the material transcend to the users, how one can create an experience through a device (Stephanidis, 2012). Usability helps in identifying problems in the system and to remedy these problems much sooner. The challenge is that every user is unique and that what would work on one does not necessarily mean it would be the same with another (Tidwell, 2010). Making applications is a difficult task and in the software development cycle adding usability can help in increasing the profit of the products developed (Bellamy, John, & Kogan, 2011). Throughout the years many solutions for user experience evaluation have been put forward to aid developers in evaluating the usability of their applications.

3.3.1 Fitts' Law

A way of designing a systems interaction is using Fitts' Law. Fitts' Law is a model that takes into account human movement in a two-dimensional target (MacKenzie & Buxton, 1992). The model was derived from Shannon's Theorem 17, which was a theorem for communication systems (MacKenzie, 1992).

According to Fitts Law shown in equation 3.1, (MT) which denotes time to move and select something from of width W in a distance of A wherein a and b are constants that is determined using linear regression (MacKenzie & Buxton, 1992). W also represents accuracy where it shows the area the action stops, the Log in the equation represents the index of difficulty (ID) (MacKenzie & Buxton, 1992).

$$MT = a + blog_2(2A/W) \tag{3.1}$$

The implication of Fitts Law can be seen in the testing the researcher did on human performance on horizontal moves towards a certain target (MacKenzie & Buxton, 1992). A sample experiment where a target's width was reduced, and it showed in the results that there was an increase in movement time over the same distance (MacKenzie, 1992).

Fitts also wanted to test the information capacity based on the humans motor (MacKenzie, 1992). The capacity which Fitts denotes as index of performance (IP) can be derived using equation 3.2 when dividing the task's index of difficulty (ID) by the movement time (MT) needed to complete the task.

$$IP = ID/MT \tag{3.2}$$

Fitts law can be used in domains like physical movement on a digital screen. In using Fitts Law, the difficulty in the user's action can be identified, and various elements of the interface that affect users when doing their tasks can be found (MacKenzie & Buxton, 1992).

In identifying the different tasks of the users, we will use this law to help us in identifying the problems in the design. Understanding this law will help in developing and organizing our assets. The computations provided will help us in measuring the effectiveness of the created user interface. It will also be used in helping to improve the interface in its different versions, as it will help in giving a metric that helps us in identifying what changes are needed to be done. In the parts of the firefly model this law will be used in measuring the gestures the child will do and if it causes extra effort and to adjust the interaction accordingly.

3.3.2 Miller's Law

As the amount of information shown at a certain times increases it creates more variance of information for someone to absorb (G. Miller, 1956). In this rule it states that information seen at once should be limited to seven but can in certain situations can be as most as nine (G. Miller, 1956).

This rule can be applied in organizing the assets in our application. This can help in reducing the cognitive load of the user and so that the child can easily identify the assets in the screen. It also helps in simplifying the design as reducing the assets helps in organizing them much better.

This law was mainly considered in the popup settings of the parts of the firefly model, it helped in making sure that the number of items that are shown on the screen is kept low when the user selects them. The way it will be implemented is by adding scroll options to the settings for the user to only see few options at a certain time.

3.3.3 Nielsen's Heuristics

Interface design has been a core component used by developers in making their products stand out from the rest. It is also an important factor in making different mobile applications marketable (Deka et al., 2017). Since this has been in the core of development, Jakob Nielsen lists down 10 usability heuristics to be followed (Nielsen & Molich, 1990; Nielsen, 1994, 2013).

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design

9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

Visibility of system status shows that whenever an action or a process is happening the system should inform the users of it. An example is in uploading something the system should clearly show the progress of the file being uploaded.

Match between system and the real world relates the design to what the user is to familiar to. It shows the user words, icons and visual cues that they will understand.

User control and freedom means that the user can easily undo or redo an action if a mistake is committed.

Consistency and standards show that there is a consistency in design for words and icons. It follows the conventions already set by most applications.

Error prevention provides the users with a good error messages to prevent the system from encountering a problem.

Recognition rather than recall helps in reducing the cognitive load of the users in using the system. The instructions on how the system should be used should be clear and the users can access them when needed.

Flexibility and efficiency of use simply means that the system is flexible to use, that it is usable by both novice and experience users with shortcuts to speed up their use.

Aesthetic and minimalist design should only show the relevant information on the screen to the user. This also helps in reducing the users cognitive load.

Help users recognize, diagnose, and recover from errors shows that the system should display information on the error message and suggest a solution.

Help and documentation should be included as it helps the users in understanding better the system. Extra information that is provided to the users will be very helpful and it should be easily accessible in the system.

All heuristics will be considered in the development of the application, but there are seven that stand that will be heavily considered in the application. The first is match between system and the real world as we would want to represent the musical elements in ways that the child is already familiar with. For the second one we would want to focus on user control and freedom since the application is on a sandbox environment we would want the child to undo the errors they commit in using the application. Third is visibility of system status and this is very important in the created application as the child needs to see the changes they made on the configuration of parts, the system should clearly show this specific change. Another for the fourth is error prevention as we would want the child to immediately understand if what they are doing is wrong. For the fifth since patterns are very important for the child to understand the application much better the consistency and standards heuristic will be helpful. Sixth is help and documentation as we are dealing with children and if they are lost in using the application having documentation to help them will be essential for them to complete their tasks. Last is Aesthetic and minimalist design as this makes sure that the assets seen in the screen is simple enough for the child to understand and to make sure that the child does not think too much when looking at them.

3.4 Musical Composition

3.4.1 The Composition Process

As discussed in the study of Collins (2005), there are four theories involving the creative process, specifically musical composition. The four theories mentioned were: (1) stage theory, (2) Gestalt theory, (3) emerging systems theory, and (4) information processing theory. It was also specified that in the application of musical composition process, Gestalt theory is the most prominent.

Gestalt theory indicates that creative thought must be divided into different sub-elements which would eventually combine to create the composition. The most important part of the process is the restructuring phase, or the 'flash of illumination' (Collins, 2005). The restructuring phase occurs when the composer realizes an unexpected solution to the problem which is then used to further advance the composition.

The study of Bennett (1976) highlights the Gestalt theory as mentioned in the study musical composition is a process that goes through several stages (see Figure 3.2). The composition begins with the germinal or initial idea it defines the theme or texture of the composition (Bennett, 1976; Collins, 2005). After the idea has taken place the sketching phase occurs and it then leads to the first draft. Yet the composer may still go back to the previous stage, even if a draft is already created as new ideas may come to the composer. As Collins (2005) described this as *backtracking* where composers go back to prior stages to refine their draft or to add their new found ideas. The next is the Elaboration and Refinement stage where the first draft will undergo revisions until the composer is satisfied (Bennett, 1976). As mentioned earlier in the study of Collins (2005) the *restructuring phase* will take place as long as the composer will think of better ideas for the composition which leads to the last stage the formation of the final draft.

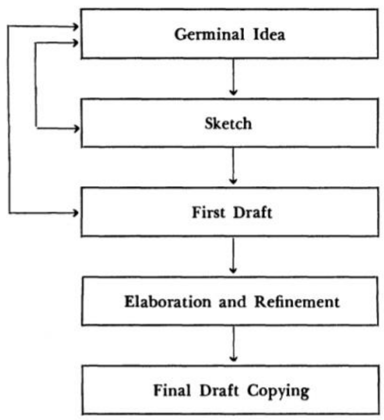


Figure 3.2: Stages of music composition (Bennett, 1976)

3.4.2 Music Fundamentals

Music as defined in the study of Willoughby (1971), is formed by combining the fundamentals of music. These fundamentals of music are discussed by Rivadelo (1986). The author named the fundamentals as: rhythm, pitch, melody, texture and harmony, color and timbre, and form.

In a composition, a sound can have a high or low tone which is related to the amount of vibrations per second, this is called pitch (Rivadelo, 1986). Pitches are represented by the first seven letters in the alphabet, namely A, B, C, D, E, F, and

G (M. Miller, 2005). The distances between a pitch from each other is illustrated as whole step, a half step, or semitone. In the keys of a piano or keyboard, moving from one key to a next key is called a half step or semitone respectively. A whole step was then described by Rivadelo as moving from one key to another and skipping the key between them. When adding the word up or down after the distance, half step, and whole step can traverse forward or backward. It is also possible to put a number before the distance in order to indicate multiple steps.

Rhythm, as explained by Rivadelo (1986), is made up of five distinguishable parts namely: clap, accent, meter, rhythmic pattern, and phrase. The clap is the key time unit used by the composition. The meter divides the claps into multiple sections. The accent is responsible for the formation of the theme of the rhythm. And lastly, the phrase is part of a musical thought, which is a component of the musical sentence.

Rhythm, as part of a composition, represents how fast or how slow the musical flow through the common patterns (Rivadelo, 1986). It is also understood that rhythm is the aspect that makes people aware of the tempo of the composition. It lets them adjust the ideas they have in order to add pitch and melody on top of the rhythm.

Another important component of a composition is the duration, which is basically the amount of time a tone or sound lasts (Rivadelo, 1986). This is seen in a composition in a staff through a note or rest. The type of note or rest indicates how long the duration of the pitch (Rivadelo, 1986).

It is also important to note that rhythm depends on the tempo of the composition. The tempo defines the pace of the composition (Rivadelo, 1986; Nelson & Christensen, 2009). Tempo is used by composers to set a mood or make the music more playable. Recently however, composers tend to use beats per minute to represent the tempo of a composition (Nelson & Christensen, 2009).

There are seven common tempo markings according to Nelson and Christensen.

- Grave, a very slow tempo. It has a bpm of around 25-40.
- Largo, a broad tempo. It has a bpm of around 40-60.
- Larghetto which is like largo but faster. It has a bpm of around 60-66.
- Adagio, a slow tempo but with great expression. It has a bpm of around 66-76.
- Andante, a walking pace tempo. It has a bpm of around 76-108.
- Moderato, a moderate speed tempo. It has a bpm of around 108-120.
- Allegro, a fast tempo it is also bright and quick. It has a bpm of around 120-156.

FireflyX will be using three of these seven tempo markings, namely *grave, adagio*, and *moderato* to indicate the current tempo of the composition. The floor bpm of the tempo markings will be used to scale the speed of the composition.

3.4.3 Musical Notation

Musical notation is the method of visually representing musical sound (G. Read, 1964). Musicians use the notations to illustrate their musical ideas. As explained by G. Read (1964), for people to be musically literate they would need to have an understanding of the symbols used in musical notation.

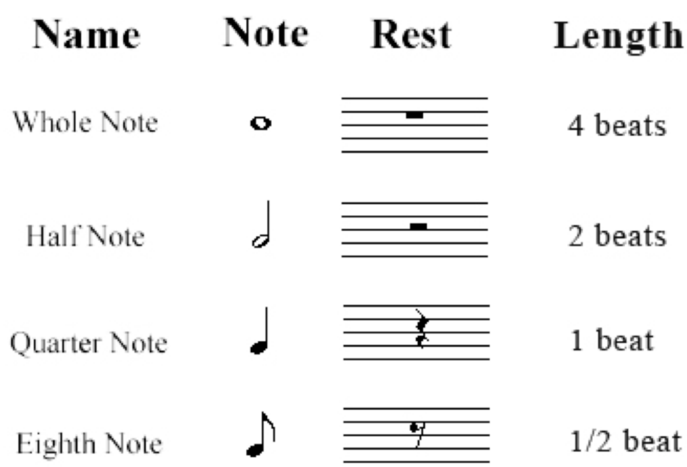


Figure 3.3: Basic notes and rests used in modern musical notation (Riso, 2016)

The notes and rests found in Figure 3.3 are some of the basic symbols in musical notation. The symbol of the notes and rests represent how long a clap is. They staff is a set of lines and spaces which indicate the levels of pitches. The notes and rests are found throughout the staff, and their position on the staff represent their pitch. However, these pitches are also based on the clef found at the start of the staff. The G-clef as seen in Figure 3.5 change the pitch represented by the staff. When it is used at the start of the staff, each line of the staff starting from the bottom represent the pitches E-G-B-D-F and the spaces represent the pitches F-A-C-E.

ITEM	NOTE	REST	VALUE (number of beats)
Dotted whole note/rest	𝅝.	𝄻.	6
Dotted half note/rest	𝅗𝅥.	𝄼.	3
Dotted quarter note/rest	♩.	𝄽.	1 1/2
Dotted eighth note/rest	♪.	𝄾.	3/4
Dotted sixteenth note/rest	𝅘𝅥𝅯.	𝄿.	3/8

Figure 3.4: Dotted notations (Hobbs, 2015)

In addition to this, the duration of the note could be extended by putting a dot after the note. When a dot is added to the note, the duration of the note is increased by half of its original value. Multiple dots could be added and the subsequent dots add the progressively halved value. Examples of dotted notations and their equivalent duration can be found in Figure 3.4.

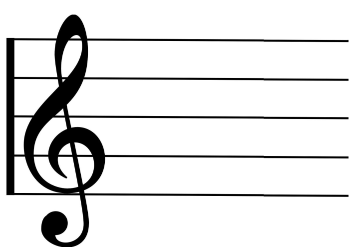


Figure 3.5: The g-clef (Estrella, 2019)

The time signature defines the distinct rhythm throughout the composition (Rivadelo, 1986). As seen in Figure 3.6, there are two numbers found in a time signature namely, the numerator and the denominator. In the time signature, the numerator always takes two spaces of the staff (G. Read, 1964; Rivadelo, 1986; Burrows, 1999).

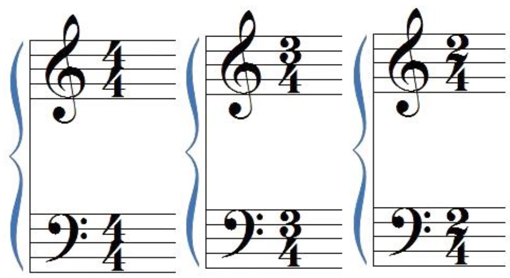


Figure 3.6: The various time signatures (Rose, 2014)

The bar lines, as seen in figure 3.7 represent the division of notes in a musical sheet. There are two kinds of bar lines in musical compositions. The first kind of bar line is one vertical line that divides the notes based on the time signature of the staff. The second kind of bar line is the double bar line which is represented by two vertical lines. The double bar line is seen at the end of a composition (G. Read, 1964).

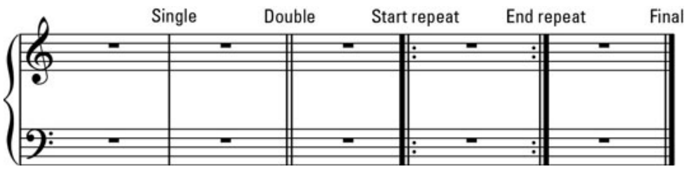


Figure 3.7: The various bar line notations (John Wiley & Sons, 2019)

3.4.4 Music Language Synthesis

Computer tools have recently been made to help in representing different elements of music, as natural languages are being made to help in representing the demands of music composition which will help in understanding music (Loy & Abbott, 1985).

One study aimed in making an open-ended programming language is the study of Dannenberg (1997) named Nyquist. The study aimed to help in creating compositional tasks. By using Nyquist, sounds can be assigned into variables, stored into data structures, and can also be passed as parameters (Dannenberg, 1997). In the study, musical composition can be represented as a series of sounds in a sequence and can be given arbitrary offsets.

In Nyquist, expressions are written using Lisp (Turetsky, 1984), where parentheses define when applying a function to a set of parameters. An expression consists of variables and keywords. An example of an expression is seen in the expression 3.3 where it simulates two notes. A reference of their keywords and representations could be seen in Table 3.4.4.

$$(sim(fminst\ g4\ 100)(fminst\ g4\ 100)) \tag{3.3}$$

Table 3.2: Representations of keywords in Nyquist

Keyword in Nyquist	Representation
defun	define function
at s t	shift sound s by t seconds in time
seq	arranges sound sequentially
sim	arranges sound simultaneously
scale	scales sound to a different amplitude
play	plays the sound
fminst	pitch depth

A thesis by Ince (2019) also emphasized in the use of patterns in representing music as they described them as events in time. These structures of music can be formed into a sequence of events, as this idea is used in specifying the music pattern in a language. Their application named Siren emphasizes on the creation of these patterns as they found inspiration from Haskell a pattern language, which generates a “library of patterns” to represent music (Ince, 2019).

FireflyX will be implementing clap-rest patterns that will represent the parts of the firefly model. Techniques in the work of Nyquist specifically music as a set of parameters will be implemented for the program to read the configuration from an XML file. The configuration will then be parsed by a playback module and produce sound.

Chapter 4

Research Methodology

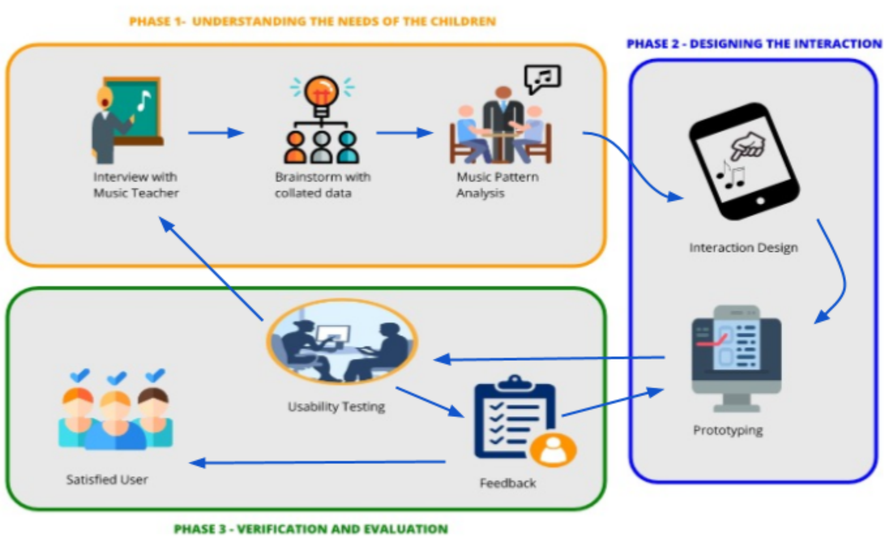


Figure 4.1: Research framework for FireflyX

The methodology for this study can be divided into three phases. The first phase (see figure 4.1 Phase 1), aims to understand the students and identify their needs with the help of their music teacher. Using the data gathered from the interview with the teachers, the next phase (see figure 4.1 Phase 2) involves the designing of the interaction to solve the needs of the students. In the last phase (see figure 4.1 Phase 3) is a constant process of testing and developing on the proposed solution based on the feedback gathered in each tests.

4.1 Interview with the Music Teacher

An interview with the music teacher of the children was done in order to understand the process of how children are taught music. The interview served as confirmation for the observations we made in the previous activity. This interview will also expand our knowledge on music and identify aspects that might not have been covered by previous observations. The interview was conducted in a secluded room where only the interviewer and the interviewee are present in order to minimize distractions in addition to this, a backup voice recorded. Observations was also written down on a notebook. The notes taken during the interview was used for discussion within the group to collate and brainstorm.

The main questions asked in the interviews are:

1. How long have you been teaching music?
2. Have you thought or are teaching children?
3. How do you start your sessions with children?
4. Do you have special techniques when teaching children?
5. Do you use the same techniques with all the children?

6. What difficulties do you encounter when you teach children?
7. Do you keep in contact with the student outside the classroom?
8. What role do the parents have in the learning journey of the child?

The questions above are non-exhaustive and may lead to more follow up questions. Different questions may be inserted or added depending on how the musician would answer a question to gather more data or insights.

4.2 Brainstorming on Collated Data

After the observation and interview, it is necessary that we analyze and process the data acquired through a meeting. All data gathered was stored on a Google Drive and a flash drive for backup in case of lost files. Based on the problem statement, we then developed ideas and shared these ideas among ourselves. The group then tried to synthesize and improve on each idea. A scenario map was made based on how the teachers perceive the learning experience of children. The scenario map highlights the process of the children using the application. Personas were also made in order to identify which helps us identify the specific needs of the personas and better suit the prototype and application in order to cater the personas. The resulting list of features and solutions would then be consulted to a music expert to determine if a prototype will be possible or usable for children.

The main questions asked in the consultation are:

1. Have you taught music to children of age 5-8?
2. What are the musical theories that children of age 5-8 should be learning?
3. What are some of the difficulties in teaching music to children?

4. How did you overcome these difficulties?
5. Do you have any suggestions on how to interact with children?
6. How did you assess the learning of the children?
7. Were the observations we made on the children accurate?
8. What areas are important to observe when conducting activities with children?
9. Was the assessment of the teacher based on our observation of the children accurate?
10. What are some suggestions you can give on how we should design our system based on our observations?
11. Do you have any suggestions on what features would be important for the application?

The questions above are non-exhaustive and may lead to more follow up questions. Different questions may be inserted or added depending on how the musician would answer a question to gather more data or insights.

4.3 Music Pattern Analysis

Rhythmic music patterns acquired from the Suzuki Book 1 will be analyzed. The most frequent clap-reset combination was taken into account and included in the Library of Patterns (Refer to Table 5.4). We also looked at music sheets for piano to help us in modeling patterns found with the integration of different pitches. We took inspiration from the idea of Nyquist to make these patterns and represent them in Swift. This also gave us an idea on which claps and notes would be used for the mapping of the firefly model. Included in this would be the amount of claps per measure, measures per section, and the amount of sections per rhythm. All of these will be considered when deciding on the possible firefly configurations.

4.4 Interaction Design and Prototyping

Using the input given by the teacher and music expert, concepts for the initial interaction design are to be sketched out on paper. The sketches will be based on how the mapping of the firefly model will be, and from the features developed from the previous activities. The sketches will also be tested first by the teacher before being implemented into a mockup. Feedback and suggestions will also be gathered to improve the sketches and mockups. Multiple designs are to be created based on how each member's ideas on how to solve the problems of the students.

Once a design was agreed upon by each member of the group, a mid-fidelity prototype is to be made using Figma to design for the proposed interface of the application based on the observation, interview, and consultations done in the previous activities. The decisions for the mappings of the firefly model will also be decided in this part. The music patterns analyzed from the activity before will be used here to decide which features from the music patterns will be mapped to a firefly part. Music fundamentals like rhythm, tempo and pitch will also be mapped to a specific firefly part.

Like the activities before, feedback will be gathered in order to improve the prototype. Even though there will be limited functionality and features in the prototype, this will give us a better idea before developing the actual application.

4.5 Implementing and Testing the Prototypes

An agile software development methodology will be implemented. The software engineering approach will be iterative, where we will take into account the feedback and suggestions of the users to improve the next iteration. A GitHub repository will be created to store and to have save points for the prototype. The prototype will be updated every time after we analyze and collate the data. Updates will be pushed to a GitHub repository when we have decided on a proper update. The GitHub repository will also serve as an access point for the members of the group.

After developing the application, usability tests will be performed with the objective of determining the overall experience in using the application. Before starting the test, the testers will first be given a consent form along as the consent from their parents. If they agree with the terms and decided to continue with the testing, they will be given a brief introduction and description of the study along with the objectives and overview. They will then be asked to use FireflyX and be assessed after. During the test we will encourage the child to think aloud as this will help us in gathering more inputs on the human factors they exhibit in doing the tasks. For the test setup these will be conducted where there is little to no audio and visual distractions. This will ensure that the users will be focused, and also to maintain the clear audio and video while recording. The latest version of FireflyX installed in a tablet iPad will be provided to the tester of the application. There will be two cameras recording the tester, the first is the camera of the laptop that records the facial expressions. This will be needed to see the reactions of the tester. The second camera records the gestures with the interaction with the application. The tasks will be written on a piece of paper that is visible for the child to see in the table. These will all be recorded using an audio recording device to capture the audio to be used for the transcription of the user testing.

The evaluation for the test will be digital and will be operated by the test moderator. The test moderator will ask the child questions and will then record the answers of the child in the form. The quantitative data will also be acquired in the evaluation mentioned earlier. This form of data is to be used in evaluating the usability data of the applications different features. This is done by the group to identify the features that have caused inconveniences for the users. The data will then be analyzed to improve the application and factor in the feedback acquired from the testing. Sample questions will be written in the different iterations of testing below. Interviews will also be done after the testing to validate the observations and also to get feedback on the user experience of the children testing the application. The adult companion and the teacher will be able to accompany and watch the child during testing.

For the first and second iteration it will be following the diagram shown in figure 4.2.

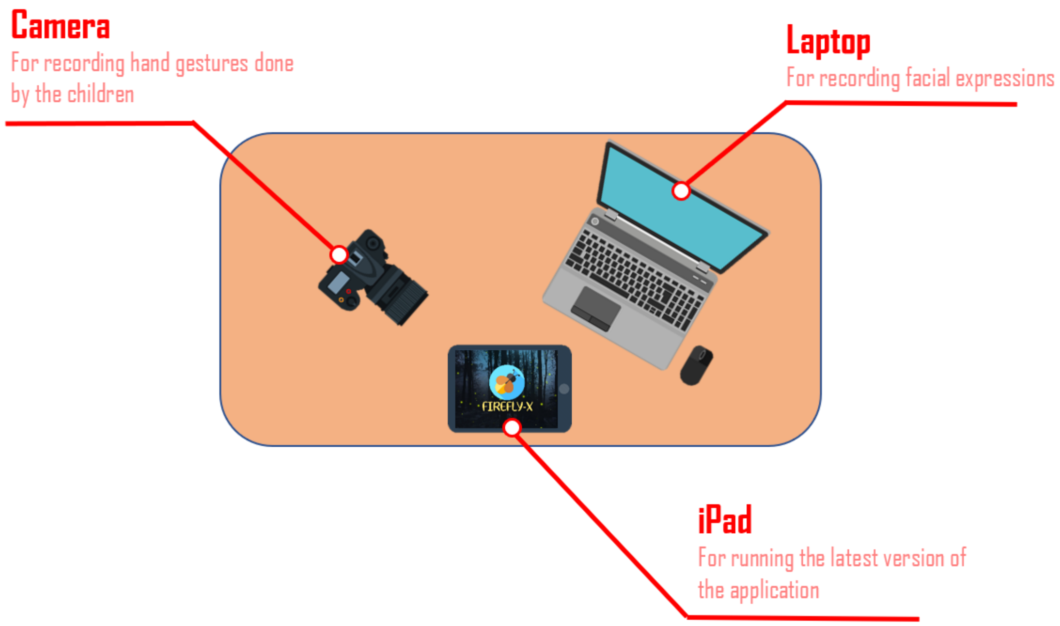


Figure 4.2: Iteration 1 and 2 test setup

The testers, music students aged 5-8 from different music schools will be asked to take part in the data collection and testing. Testing will be divided into three (3) phases with each iteration having a set of different tasks since more features are to be added in the application per iteration.

Tasks that will be asked to do will be modeled from the use cases found in Appendix D.

4.5.1 First Iteration

After developing the application which is 60% complete, it would be tested with three (3) users. Since the functionality at this iteration is still at 60%, we would like the users to test mainly on the fundamental functionality with only one firefly. These tasks revolve around the manipulation of the parts/functionality of the firefly. To meet 60% completeness namely the tail (pattern), wing (repetition), body (tempo), wing (note speed), and the playback engine.

These are examples of tasks that will be asked to be done for the first iteration:

- Set the tempo of the firefly by choosing a body type
- Set the number of repetitions of the firefly by choosing a setting in the right wing
- Set the speed of note of the firefly by choosing a setting in the left wing
- Set the blinking pattern of the firefly by choosing a tail type
- Replace the tempo by selecting a different body type
- Replace the current repetition by selecting a different setting in the left wing
- Replace the current speed of note by selecting a different setting in the right wing
- Replace the pattern by selecting a different tail type
- Tap start to start playing the firefly
- Tap stop to stop the firefly from playing
- Tap on the power button to exit to main menu

These are the sample questions in the evaluation with the scale being 1 being the easiest to 5 being difficult. We will be asking these to tester to better understand the functionality of the first iteration:

- How difficult was it to set the tempo?
- How difficult was it to set the repetition?
- How difficult was it to set the speed of the note?
- How difficult was it to set the clap-rest pattern?
- How difficult was it to replace the current tempo?
- How difficult was it to replace the current repetition?
- How difficult was it to replace the current speed of the note?
- How difficult was it to replace the current clap-rest pattern?
- How difficult was it to start playing the firefly?
- How difficult was it to stop to stop the firefly from playing?
- Was it difficult to go through the application?
- Do you like the design of the application?
- Was the functionality of the parts clearly seen?

4.5.2 Second Iteration

In the second iteration we would then test the application that is 80% complete with seven (7) testers. From the seven testers three of them will be retained from the first iteration of testing, meaning we would have four new participants for this iteration. In this iteration we will be implementing the changes based on the comments received from the first iteration of testing. The aim is to be 80% wherein there will still be one firefly playing. Functionalities such as pitch and release to canvas, in addition with the ability to manipulate the firefly parts will be added to meet the 80% completeness.

The tasks from the first iteration will carry on in the second iteration testing. These are examples of newly added tasks that will be asked to be done for the second iteration:

- Tap pause to pause the firefly from playing
- Tap resume to resume the playing of the firefly
- Tap the jar to replay previous fireflies
- Tap on the Feed Me Button to start changing the pitch
- Set the pitch of each note by dragging the biscuit on the tray to the staff
- Start replacing the current pitch of a note by clicking Feed Me button again
- Replace the current pitch for one or more notes by dragging the biscuit/s to a higher line in the staff
- Replace the current pitch for one or more notes by dragging the biscuit/s to a lower line in the staff
- Clear the pitch for all notes by selecting the Clear button
- Preview the pitch representation of the firefly by selecting the Preview button

These are the sample questions in the evaluation with the scale being 1 being the easiest to 5 being difficult. Aside from the questions that we will ask again that came from iteration 1 we will be introducing these new questions to the tester to better understand the functionality of the second iteration:

- How difficult was it to pause the firefly from playing?
- How difficult was it to resume the playing of the firefly?
- How difficult was it to to replay previous fireflies?
- How difficult was it to set the pitch?
- How difficult was it to replace the current pitch to a higher position in the staff?
- How difficult was it to replace the current pitch to a lower position in the staff?
- How difficult was it to clear all pitches?
- How difficult was it to preview the pitch playback?

4.5.3 Third Iteration

Lastly in the third iteration, fifteen (15) users will be testing the complete application. Where same as the second iteration we will retain the seven users that already have tested the application previously and we will get eight new participants in this last iteration. The last stage revolves on improving the functionality from the first two stages. Functionality in this stage for it to be fully complete should already handle five (5) fireflies as well as saving and loading the workspace. The tasks will also use the same as the first two iterations and also adding the new functionality developed in this last iteration. For the last iteration since new tasks on composing will be added we will be also adding a music sheet in the test setup as seen in figure 4.3.

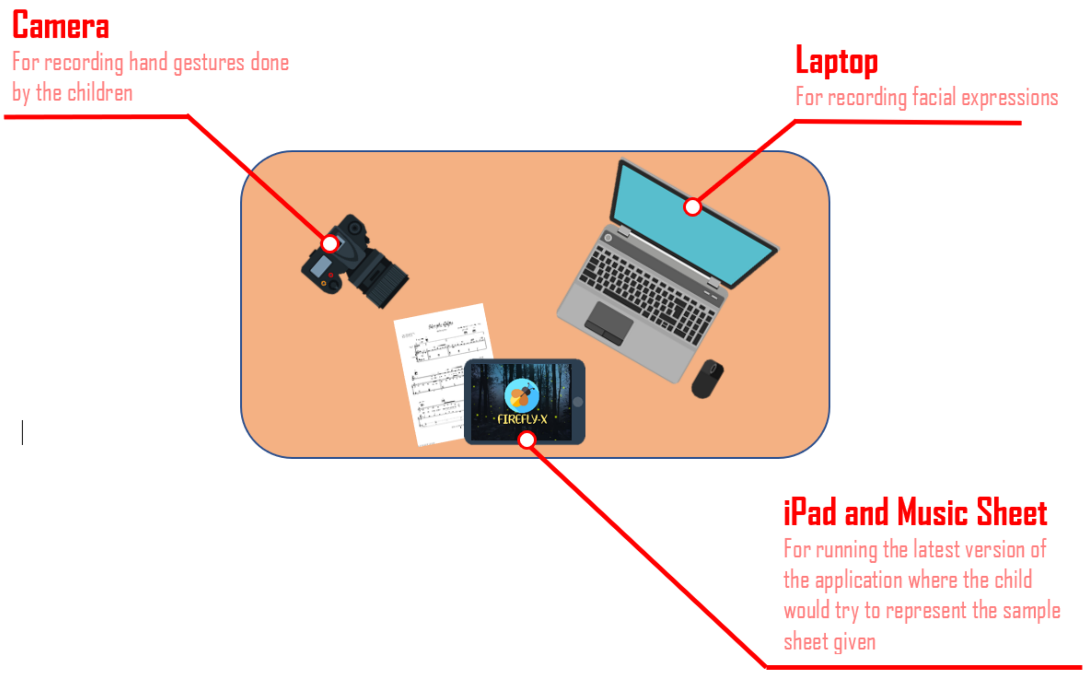


Figure 4.3: Iteration 3 test setup

The tasks from the first and second iteration will carry on in the third iteration testing. These are examples of newly added tasks that will be asked to be done for the third iteration:

- Tap Reset Album to reset the fireflies
- Tap Save to save the modified fireflies

- Tap Load to load previously made fireflies
- Configure the fireflies to emulate a sample sheet given by the testers (Hot Cross Buns)
- Configure the fireflies to make a simple familiar song like (Twinkle Twinkle Little Star/Happy Birthday)
- Edit the fireflies to modify a previously made track
- Free play of the environment
- Configure five fireflies

These are the sample questions in the evaluation with the scale being 1 being the easiest to 5 being difficult. Aside from the questions that we will ask again that came from iteration 1 we will be introducing these new questions to the tester to better understand the functionality of the second iteration:

- How difficult was it to to reset the fireflies?
- How difficult was it to save the modified fireflies?
- How difficult was it to load previously made fireflies?
- How difficult was it to copy the sample sheet Hot Cross Buns using the fireflies?
- How difficult was it to modify a previously made track?
- How difficult was it to freely play the application?
- How difficult was it to configure the five fireflies in an environment?
- How would you rate the learning you got from the application?

4.6 Gantt Chart

Table 4.1: Timetable of activities

2019 - 2020	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Planning	●	●	●	●												
RRL	●●●●	●●●●	●●●●	●●●●												
Interview					●●●●	●										
Preliminary Results and Analysis						●●●●										
Learning Swift							●●●●	●●	●●●●							
Development						●●●●	●●●●	●●●	●●●●	●●●●	●●●●	●●	●●●●	●●●●		
Experiment Design										●	●●			●●	●●●●	
Results and Analysis					●●	●●●●	●					●●●	●●		●●	●●●●
Documentation	●	●	●	●	●	●	●	●	●	●	●	●	●●		●●●●	●●●●

Chapter 5

FireflyX: Features and Design

5.1 System Overview

FireflyX is a mobile application tool that aims to aid children in learning music fundamentals. There will only be one role, which is the user. The target users are children of ages 5 to 8 with varying knowledge in music. The user may edit the firefly models' parts based on their preferences.

The properties of the rhythm that can be configured on the firefly model are the tempo, length of the note, repetitions, rest pattern, and pitch. Each part of the firefly model directly corresponds to one property that can be modified.

The parts of the firefly model may be configured either by part or by manipulating the parts by gestures, such as dragging, swiping, and tapping. After a firefly model is configured, the user may set it free on a canvas where they can freely fly and roam. The rhythm will then be played with the properties set by the different parts the user has chosen or have tweaked.

In order to create a rhythm, the user is allowed to make more firefly models with different configuration. The user will be allowed to play jar, load jars, preview, clear, edit previous firefly, and save their current jars.

5.2 System Objectives

The system aims to accomplish the following:

- To enable users to make a rhythm and pitch using firefly models.
- To allow users to change the properties of the rhythm and pitch by tweaking the parts of the firefly model.
- To allow users to start playback by releasing the firefly models.
- To allow users to save and load their current jars.

5.3 System Scope and Limitations

The users can make rhythms by modifying the firefly models. We will only include rhythms and pitch, specifically claps and rests, no harmonies. The properties of the music can be modified by tweaking the parts of the firefly model.

The tempo of the firefly model can be chosen by the changing the body model. The body will be including only the three tempos used namely *grave, adagio*, and *moderato*. This will be the only tempos available because the common children songs have around 100 to 120 bpm, these songs are also taught to children with a lower bpm so that the children could follow along. The wing speed can be set by buttons to change the length of the note. The slower wing will represent slower notes and the faster wing will represent faster notes. For setting the repetition of the pattern, the wing size can be selected. The bigger sized wings will represent more repetitions, and the smaller sized wings will represent less repetitions. The speed and sizes will only be integers. The light of the firefly model is the pattern for the rests of the note. The number of patterns can be seen in Table 5.4. Also the pitch will be represented by the candies scattered in the environment.

Each workspace will be considered as a jar. The user is given five fireflies in jar to play with. After the user modifies the firefly models, they can be released outside the jar. Only five fireflies may roam outside freely, where the firefly will traverse through a trail which leads to it moving to another note's pitch. After the fireflies that are currently playing are finished, they will be automatically be saved as a track. The track will be added to the track list. The track will be represented also as a jar.

The users will be able to listen to previous tracks by loading them in the environment. The users are allowed to save their current workspace. The saved file will include the current album and the configurations of the fireflies. A JSON file format will be used for the saved files. These saved data can be loaded by the user at any time. Each save will ask the input for the title of the jar.

5.4 Architectural Design

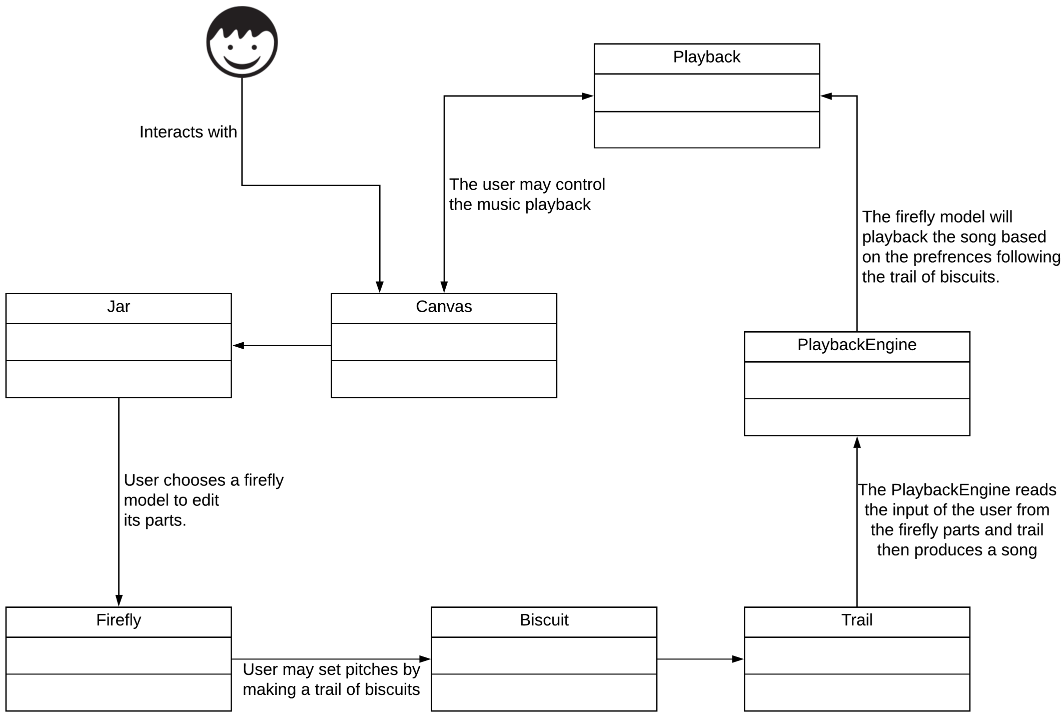


Figure 5.1: The System Architecture of FireflyX

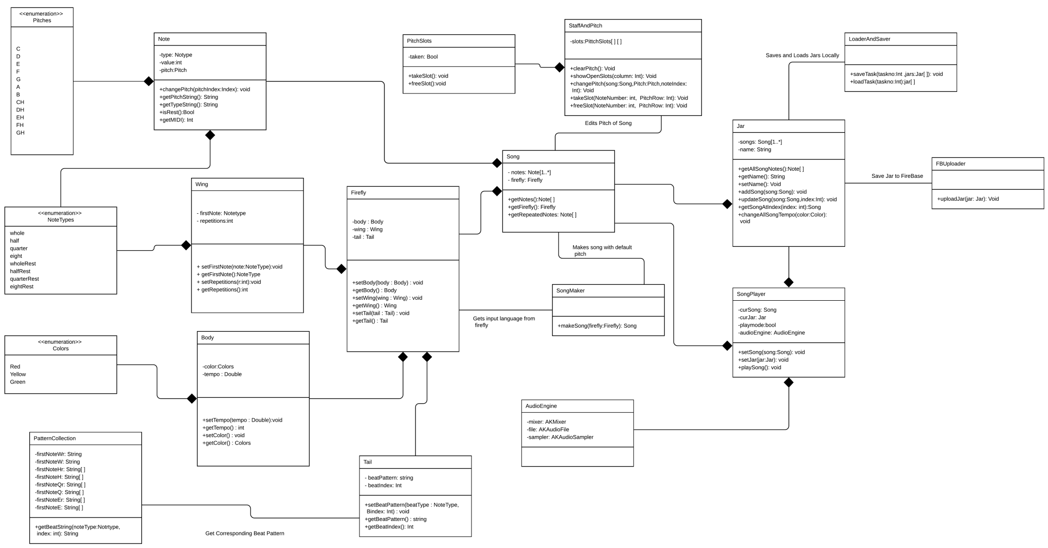


Figure 5.2: UML class diagram of FireflyX

Figure 5.1 and Figure 5.2 shows the architecture of the system. The system follows a Model-View-Controller architecture. Most of the process will be handled locally by the device, but due to the pandemic we added a feature that saves their work on an online database. Figure 5.2 shows the detailed class diagrams for the system.

5.5 System Features

The following are the features of the FireflyX application. Features such as firefly model parts popup settings, playback toolbox, jar sandbox environment, and the canvas.

Body Popup Settings

The body section of the firefly model can be tapped to show the popup settings. In the popup settings of the body section, the user is able to choose the tempo of the firefly. There are three colors that the user can choose from namely Red, Yellow, Green with 25, 60, 100 bpm respectively. These colors were chosen because we believe that the children are more familiar with these colors due to stoplights. The user can also scroll through a variety of body colors. The preferences of the body will be appended to the string of rhythm pattern language. For every environment once a body has been set for the first firefly the succeeding fireflies will have the same color with the first and by changing one the others get changed as well.

Wings Popup Settings

The wing section of the firefly model can be tapped to show the popup settings. In the popup settings of the wings section, the user is able to choose the speed of the note being played by pressing 1, 2, 4, and 8 which represents the whole note, half note, quarter note, eighth note, respectively or a picture of their notes itself. The size of the wing will represent the number of repetitions. The minimum size is 1 and the maximum size is 6. The wing preferences will be appended to the string of rhythm pattern language.

Tail Light Popup Settings

The tail section of the firefly model can be tapped to show the popup settings. On the right side, the user is able to change the rest pattern of the note being played. The tail lights will be representing the patterns and pattern can be previewed in a tail popup settings below, the light will be based from the chosen color in the body. The patterns will be predetermined by our library of patterns. The chosen pattern will be appended to the string of rhythm and pitch pattern language.

Set Pitch Mode

The mode is only accessible upon tapping the feed me button. The feed me button can be accessed during the tail pop settings. There will be a staff where the candies may be placed. The candies will be representing the notes. The number of candies will depend on the number of claps in the chosen pattern. The placement of the notes will also be determining the flight pattern of the firefly model. The preview button will also act like a playback for one specific firefly. The clear button will allow the user to reset the candies. The chosen pitch pattern will be appended to a separated pattern language.

5.5.1 Jar Sandbox Environment

The sandbox environment will be represented by a jar. In the jar, five firefly models can be seen where each can be tapped. When a firefly model is tapped, it enlarges and enables the popup settings when a specific part is tapped. The cork can also be tapped to release all of the firefly models into the canvas.

5.5.2 Canvas

Once the jar lid is tapped, the finished firefly models are released into the canvas where they roam around and play music based on their settings by sequence. Once the firefly models on the canvas are done playing they will be automatically be added to the list of jars.

5.6 Music Language, Rules and Library of Patterns

Table 5.1: Rhythm representation

note representation	music notation	integer equivalent
W	Whole Note	1
H	Half Note	2
Q	Quarter Note	4
E	Eighth Note	8
Wr	Whole Rest	-1
Hr	Half Rest	-2
Qr	Quarter Rest	-4
Er	Eighth Rest	-8

Table 5.2: Pitch representation

pitch of note	pitch representation
c	(63)
d	(65)
e	(67)
f	(68)
g	(70)
a	(72)
b	(74)
c1	(75)
d1	(77)
e1	(79)
f1	(80)
g1	(82)
a1	(84)
Rest	(-)

Table 5.3: Tempo representation

Name of Tempo	Beats Per Minute
Grave	25 bpm
Adagio	60 bpm
Moderato	100 bpm

To help us better understand the music sheets from the Book 1 of the Suzuki teaching method, we decided to convert the sheets to a language we can easily understand and represent on code. See Table 5.1 for reference to the converted language. This will mainly be used for the representation for the first iteration since at this iteration it only covers rhythm. To make the application easier to use, a set of rules for the music composition has been used. The firefly will only be using a maximum of six measures per rhythm. Each measure is equal to one pattern. The speed of the notes and rests that will be supported by the application will only be the whole, half, quarter, and eighth note.

The following patterns are taken from the Book 1 of the Suzuki teaching method, included here are the three most common clap and rest patterns found in each clap and rest combination (see Table 5.4). For the representation in the table, 1 is for the clap and the 0 is for the rest. An example as seen from the table is "1Rest" - the number 1 coefficient represents the number of instances of the rest. A change in pattern from rest to tap is separated by a dash.

For iteration two and three, since pitch will already be added we would use the same set of patterns and add a corresponding pitch (from C major scale) to a value in Swift audioKit denoted inside a parenthesis from the pitches found in Table 5.2 and also how to represent ones from a rest. An example pattern is shown through part of two sample pieces of music (found in Appendix F), the sample representation is seen in Table 5.5.

Table 5.4: Common patterns in Suzuki Book 1

Pattern	**Pattern Name**	**Count**	**Pattern Note Count**
0	1Rest	23	[Wr - 23]
1	1Clap	1	[W - 1]
001	2Rest-1Clap	12	HrQrQ - 12]
010	1Rest-1Clap-1Rest	6	[QrQHr - 5, HrQQr - 1]
100	1Clap-2Rest	2	[QQrHr - 2]
1010	1Clap-1Rest-1Clap-1Rest	39	QQrQQr - 39]
1111	4Clap	22	[QQQQ - 21, EEQH - 1]
1110	3Clap-1Rest	5	[QQQQr - 5]
10110	1Clap-1Rest-2Clap-1Rest	26	QQrEEQr - 26]
11111	5Clap	10	[QEEQQ -4, QQQEE -3, EQEQQ- 1, EEQQQ -1, EQQQE -1]
01101	1Rest-2Clap-1Rest-1Clap	13	[QrEEQrQ -13]
110110	2Clap-1Rest-2Clap-1Rest	20	EEQrEEQr - 20]
111111	6Clap	3	[EEQEEQ - 2, QQEQQE - 1]
011011	1Rest-2Clap-1Rest-2Clap	6	[QrEEQrEE - 6]
1111111	7Clap	14	EEEEEEQ - 11, EEQEEEE - 3]
0101011	1Rest-1Clap-1Rest-1Clap-1Rest-2Clap	4	[ErEErEErEQ - 4]
0111011	1Rest-3Clap-1Rest-2Clap	2	[ErEEEErEQ - 2]
11110110	4Clap-1Rest-2Clap-1Rest	4	EEEEErEEEr - 4]
11111111	8Clap	3	[EEEEEEEE - 3]

De La Salle University

Table 5.5: Some patterns found in Hot Cross Buns and Old Macdonald

Pattern	Pattern Name	Count	Pattern Note Count (with Pitch)
0	1Rest	1	[Wr(-) - 1]
10	1Clap-1Rest	1	[H()Hr(-) - 1]
111	3Clap	3	[Q(b)Q(a)H(g) - 3]
1110	3Clap-1Rest	1	[Q(g)Q(g)Q(g)Qr(-) - 1]
1111	4Clap	1	[Q(b)Q(b)Q(a)Q(a) - 1]
11111111	8Clap	1	[E(b)E(b)E(b)E(b)E(a)E(a)E(a)E(a)]

5.7 Data Design

Each selection of the firefly body part corresponds to an integer that references into a music library to get the necessary music files needed for the playback. The chosen format for the save files will be using JSON. The file will be saving all the configurations of the current fireflies on the canvas. The file can be loaded and it will load the fireflies with their configurations that were saved on the file. The saved files will be stored locally on the device. Allowed inputs for the files can be seen in the table below in Table 5.6. An example JSON file is also shown in Table 5.7 that shows how the sample piece Hot Cross Buns seen in Appendix F will be saved.

Table 5.6: JSON data design

```
jarObject : {
    "JarName" : "Hot Cross Buns",
    "Tempo" : 60,
    "Fireflies" : {
        "Firefly1" : {
            "Beat Pattern" : "Q Q H",
            "Pitch Pattern" : "b a g",
            "Repetitions" : 2
        },
        "Firefly2" : {
            "Beat Pattern" : "E E E E E E E E",
            "Pitch Pattern" : "b b b b a a a a",
            "Repetitions" : 1
        },
        "Firefly3" : {
            "Beat Pattern" : "Q Q H",
            "Pitch Pattern" : "b a g",
            "Repetitions" : 1
        }
    }
}
```

Table 5.7: JSON data design specifics

Variables	**Possible Values**	**Description**
JarName	string	This contains the album name that is specified by the user.
Tempo	integer	It represents the tempo of the firefly, the colors are limited to the three colors imitating stoplights which are red,yellow, and green.
Fireflies	array	This contains the array of fireflies that are configured by the user which has a maximum of 5 fireflies per jar. Inside the array are the configured beat pattern, pitch pattern, and number of repetitions that was made by the user.
Beat Pattern	string	This contains the beat-rest pattern. For example a beat of QQQQ which is a 4Clap pattern with a count of 4.
Pitch Pattern	string	This contains the pitch pattern which is retrieved from the making of the candies that represent the different pitches.
Repetition	integer	This represents the configured right wing which is the number of times or repetitions the firefly will play once released to the environment.

De La Salle University

5.8 Screen Flows

5.8.1 Splash Screen

Figure 5.3: Splash screen

The Splash Screen is the first screen shown to the child when the application is opened. The splash screen will last for three seconds.

5.8.2 Home Screen

Figure 5.4: Home screen

The Home Screen (figure 5.4) is the next screen that will show after the splash screen, here the child may tap between five buttons, namely: Task #1, Task #2, Task #3 ,Task #4 ,and Task #5. This is where the child will be doing the tasks for testing.

5.8.3 First Firefly Screen

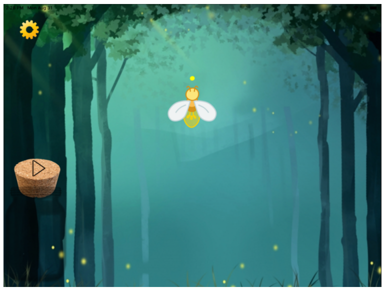


Figure 5.5: First firefly

After going in to a task, the child will be greeted by a forest environment and a single firefly. This will be the first firefly that the child can play around with and tweak to their heart's content.

5.8.4 Firefly Body Selection

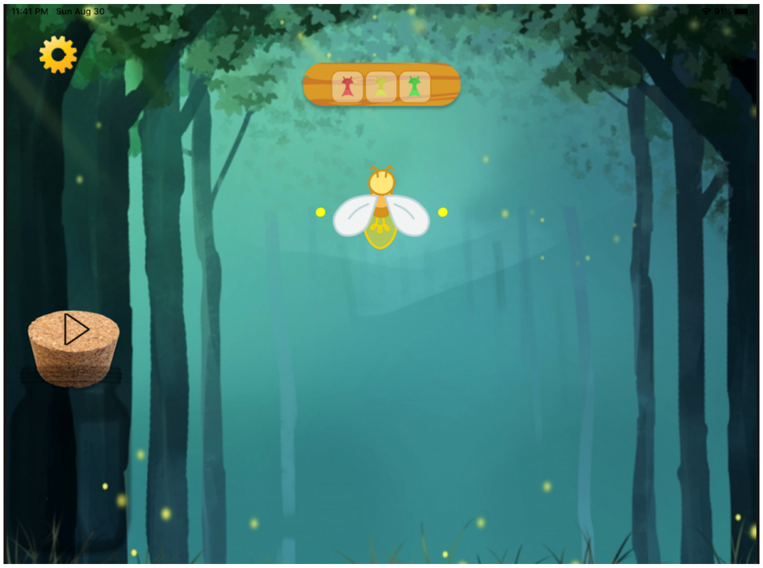


Figure 5.6: Body popup

When the child taps the body part, they can choose from three different colors that represent different tempos.

5.8.5 Firefly Right Wing Selection

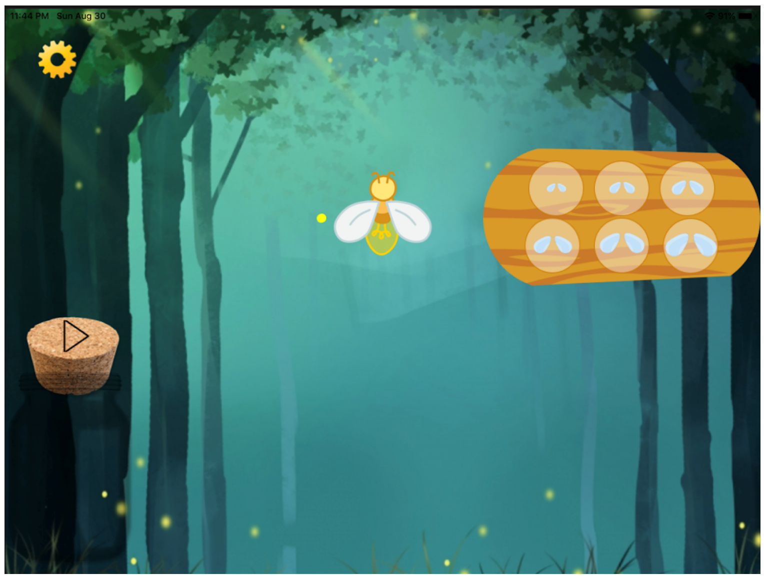


Figure 5.7: Right Wing popup

When the child taps the right wing, they will be able to choose how many times the firefly will play the pattern.

5.8.6 Firefly Left Wing Selection

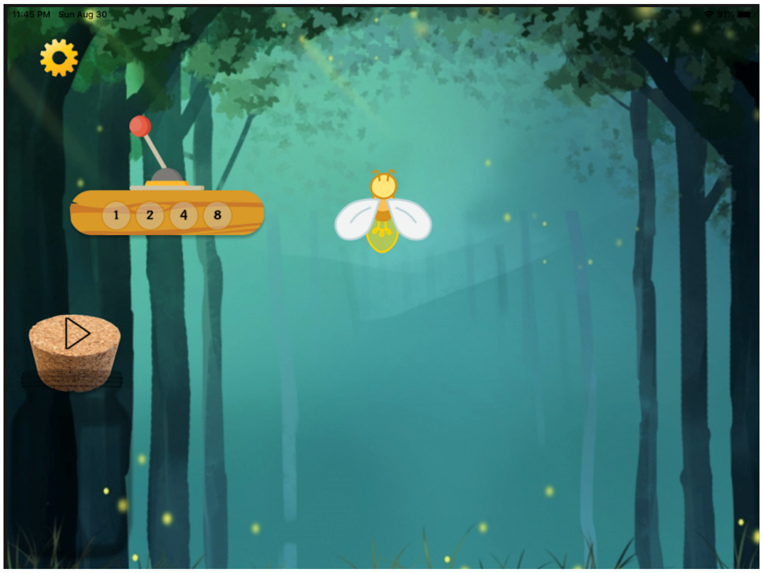


Figure 5.8: Left wing popup notes

When the child taps the left wing, they will be able to choose the first note to play.

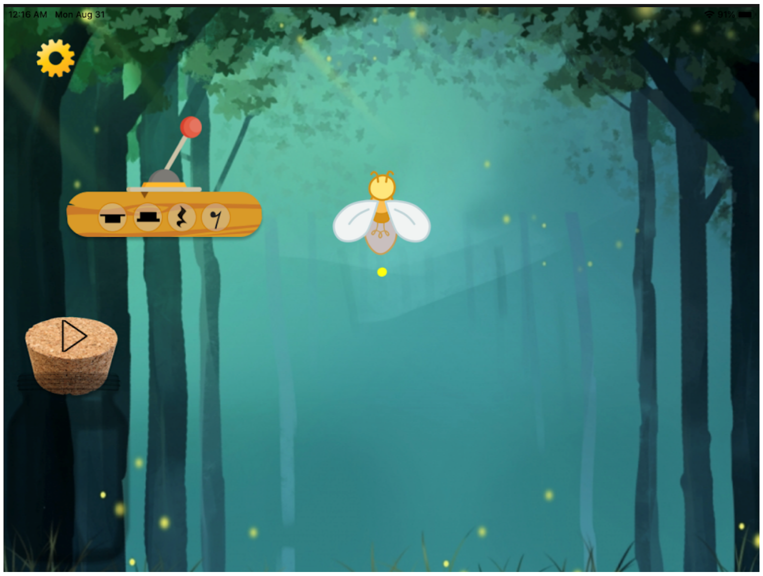


Figure 5.9: Left wing popup rests

The lever can be toggled to show the rests.

5.8.7 Firefly Tail Selection

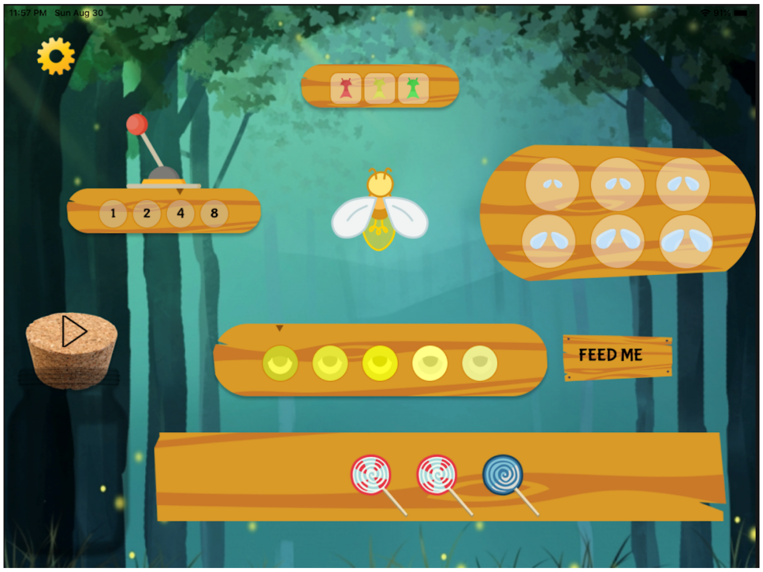


Figure 5.10: Tail popup

When the child taps the tail, they will be able to choose the patterns based on their first note. The child will be able to see the preview of the candy patterns.

5.8.8 Feed Me

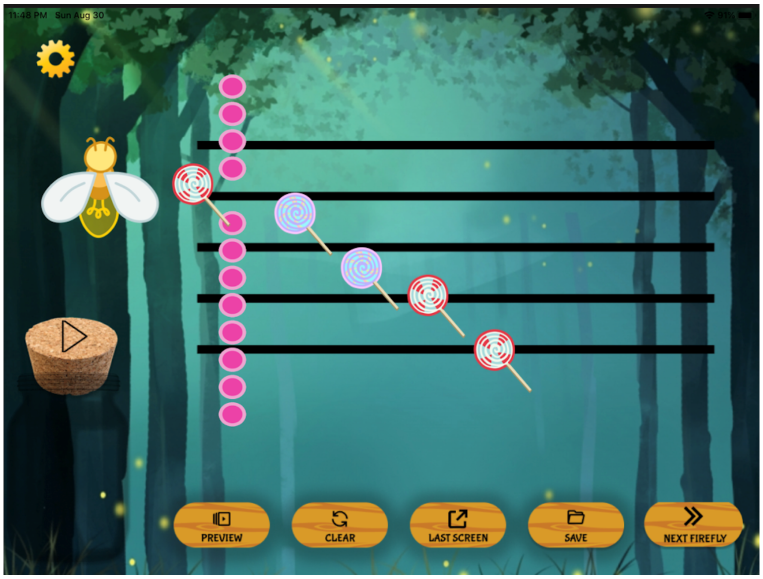


Figure 5.11: Left wing popup notes

After choosing the pattern, the child can tap the feed me button which brings up the staff where they can place the candies to give the firefly pitches. In this screen, there is also a preview button which plays the current firefly to see how it will sound like. The clear button resets the candy placements. The last screen button allows you to go back to editing the firefly. The save buttons saves the current firefly configuration. The next firefly button will go to the next editable firefly.

5.8.9 Menu Settings

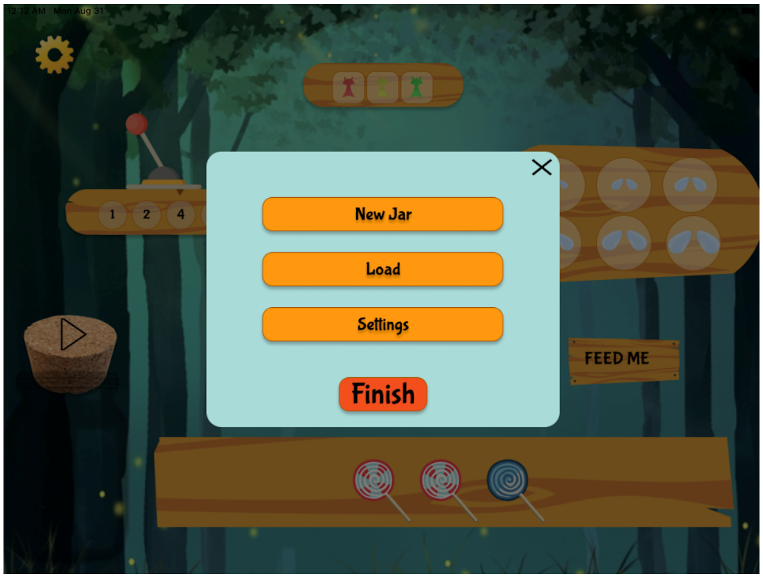


Figure 5.12: Settings

When the child taps on the gear icon, this will bring up a popup menu where can tap three different buttons. The new jar button will create a new jar of fireflies. The load button will allow him to load previously saved jars. The settings button will allow him to change some preferences.

5.8.10 Visual Settings

Figure 5.13: Visual settings

After tapping the settings button, the child may toggle the speech bubble guide and toggle to use numbers or notes for the left wing.

5.8.11 Load Screen

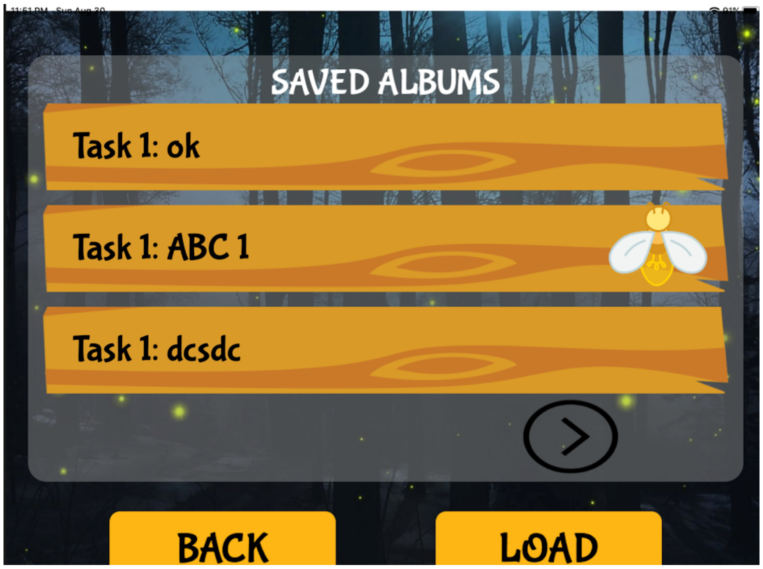


Figure 5.14: Load screen

After tapping the load button, this brings up the previous jars that the child made and can load from his previous saves.

5.9 Deployment Plan

FireflyX will be developed using Xcode using the Swift language. The application once compiled can be uploaded to the Apple App Store where anyone may download the application for free. We will then use TestFlight to distribute our application. This is because Testflight allows for remote testing. To use TestFlight, we will upload beta builds of FireflyX, and invite testers using their email addresses. Testers will then check their email to accept the invitation to test the application. In order for the testers to install FireflyX, They will have to use the TestFlight application in their iPad after accepting the invitation in their email.

The files will then be saved locally this includes the songs and their respective jars, these files will be exportable with the use of the JSON. Using the JSON another user in a different iPad can retrieve the same environment by loading the JSON sent. This will be done since the application is also connected to Google's Firebase storage to save the data online in JSON format. A diagram showing the deployment plan is shown in figure 5.15.

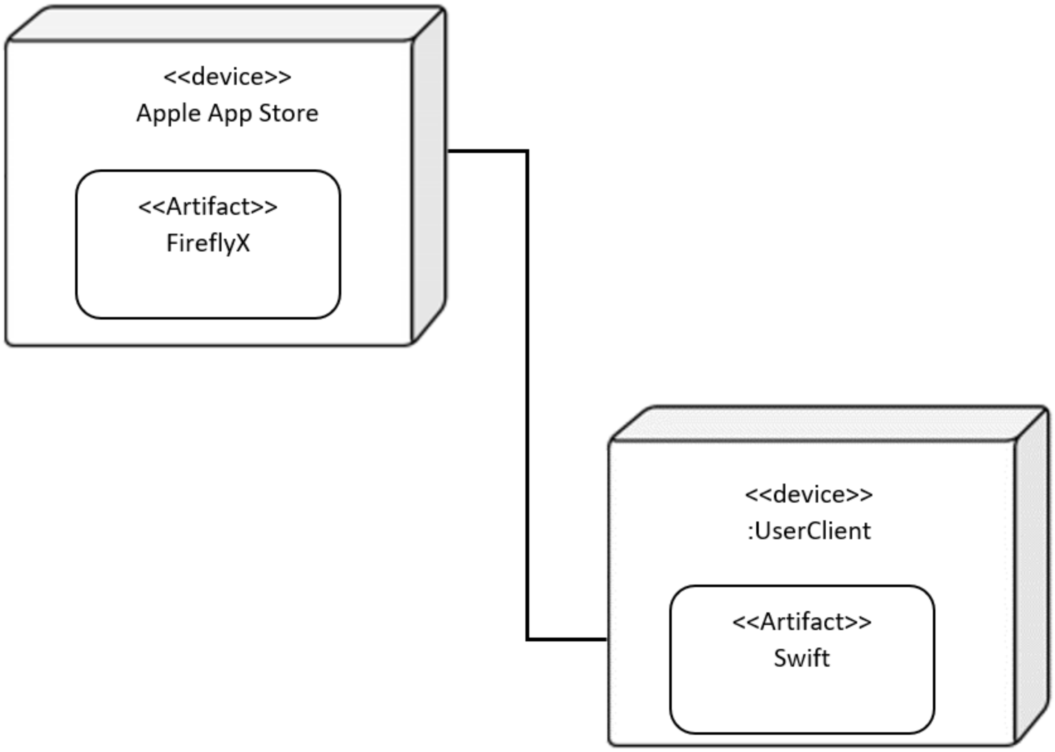


Figure 5.15: FireflyX deployment plan

Chapter 6

User Study

6.1 Usability Test Objectives

We conducted a user study in order to do the following: (1) test the usability of FireflyX, and (2) discover the human factors that children exhibit when using a sandbox mobile musical tool. The user study involved several phases namely (1) Participant Recruitment, (2) usability tests, (3) post testing, (4) expert evaluation and (5) analysis of data. Each objective and phase is described in the succeeding sections.

6.2 FireflyX Testing

6.2.1 Participant Recruitment

Children between the age of five to eight years old were recruited. These participants were recruited using convenience sampling. We collected specific information from the participants such as gender, age, prior training in music and handedness. These details could be seen in Table 6.1. Prior knowledge in music was categorized between none to familiar as seen below.

- None - no prior knowledge in music at all
- Minimal - the child has seen music notes but could not recognize them individually
- Slightly Familiar - the child can recognize rhythm and pitches present in FireflyX but have not memorized it
- Familiar - the child has memorized the notes, rhythm, and pitches present in FireflyX

Due to the Covid-19 pandemic, participant recruitment and testing has to be done online and remotely. As such, locations of participants did not matter as long as timezones allowed them to participate.

We were able to initially recruit 14 participants through our sampling method. Only eight out of the original 14 attended the orientation after they were contacted. Only six were able to successfully install the mobile application remotely. The other two encountered hardware problems that made them unable to participate any further. Five (5) participants were able to successfully finish the test protocol while the sixth participant decided to withdraw from the study.

Participant	age	sex	dominant hand	prior knowledge in music
P1	7	M	right	None
P2	8	M	left	Minimal
P3	6	F	right	Minimal
P4	6	M	right	None
P5	8	M	right	Slightly Familiar

Table 6.1: Participant demographic information

6.2.2 Usability Testing

Due to the complications brought by the Covid-19 pandemic, the testing protocol from the first and second iteration were not operationally-feasible. This meant that we had to rely on testing the application remotely. This was done by deploying the latest version of FireflyX via TestFlight. Participants are scheduled into several sessions such as orientation session, task sessions and post testing sessions. Participants will be given instructions and preparations during the orientation session. The application will be installed and downloaded to the devices of the participants remotely. In task sessions, the participants will undergo usability testing while performing the pre-designed tasks in the next sections. There will be five (5) tasks that are progressing in terms of difficulty. These tasks were designed with the help of our music experts and early childhood music teachers. In the post-testing session, the participants will be interviewed and asked to evaluate FireflyX using AttrakDiff.

The orientation given to the participants and their guardians mainly focused on discussing their rights as a participant, the motivation of our research, the objective of our research, and the tasks that will be given to the child. Profiling of the child is also done at this part. After these, if time is still sufficient, we ask the child to do the first task which is to explore and play with the application. During this, we guided the child on how to compose the alphabet song while teaching them the different functions of the application. The music sheet for the alphabet song can be seen in Figure 6.1

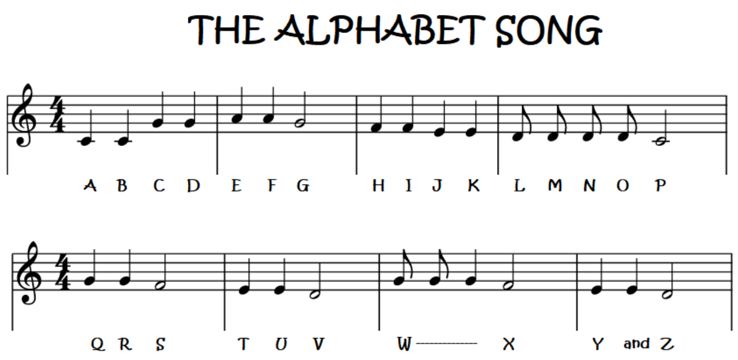


Figure 6.1: Sheet representation for the English alphabet song.

The second task given to the child aims to familiarize them with the different rhythm and patterns present in music. The child is asked to compose the basic rhythm sheet which can be seen in Figure 6.2. The child is also given an audio file which they can listen to, in addition to the different visual tips which can be seen in Figure 6.3 to Figure 6.7. The child is expected to finish the task with minimal guidance given to them by their guardians. No other forms of intervention that help the children will be given other than referring them to the tips and guides provided.

Figure 6.2: Basic rhythm music sheet

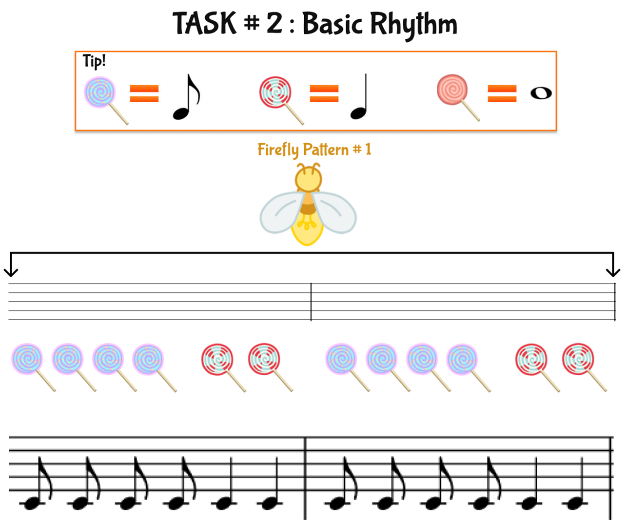


Figure 6.3: Basic rhythm tip 1

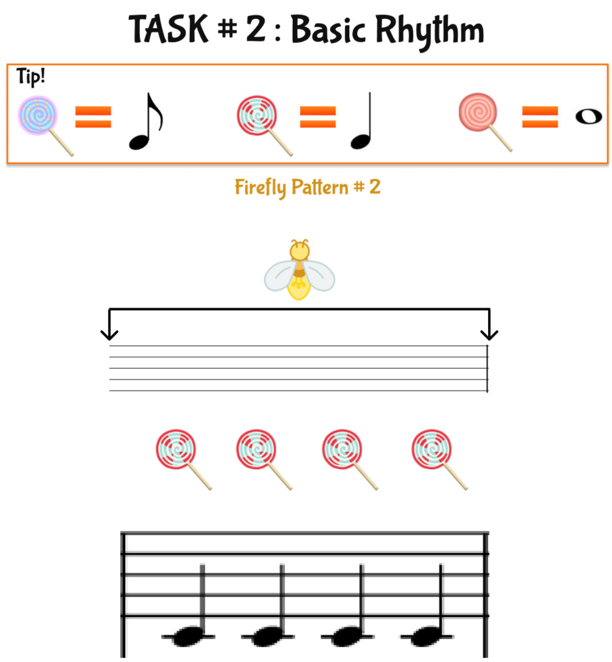


Figure 6.4: Basic rhythm tip 2

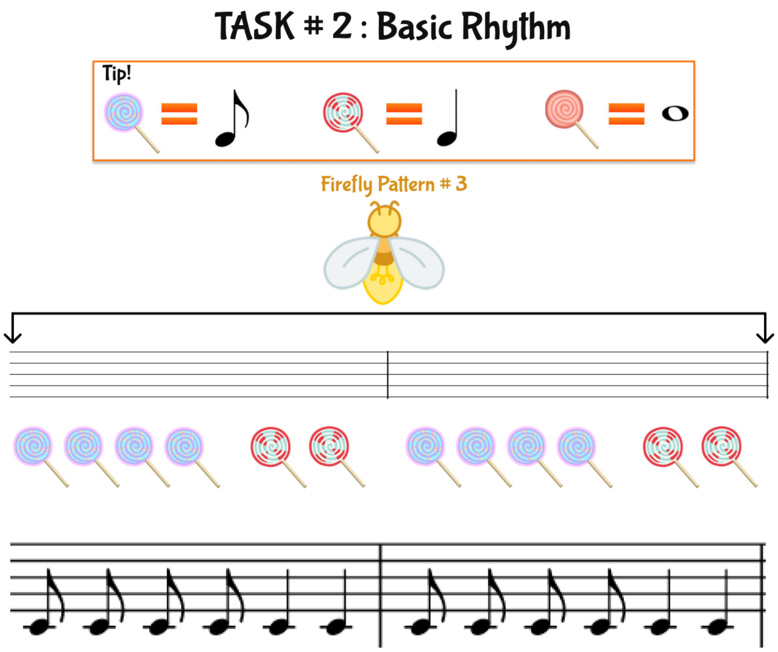


Figure 6.5: Basic rhythm tip 3

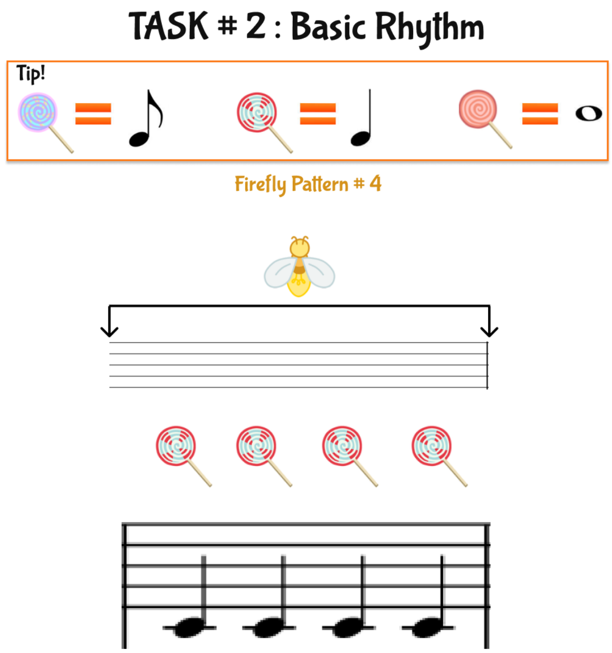


Figure 6.6: Basic rhythm tip 4

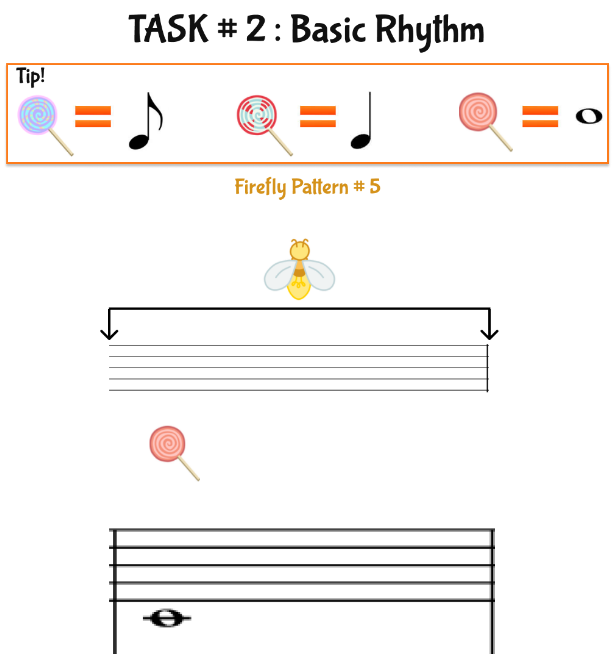


Figure 6.7: Basic rhythm tip 5

The third task given to the child aims to familiarize the them with the usable pitch in the application. Similar with task 2, the child is asked to compose the basic pitch sheet which can be seen in Figure 6.8. The child is given an audio file which they can listen to, in addition to the visual tips which can be seen in Figure 6.9 to Figure 6.18. Like in task 2, the child should be able to finish the task with minimal guidance from their guardians. We are also expected to not give any advice or help aside from referring them to the tips given to them.

Figure 6.8: Basic pitch music sheet

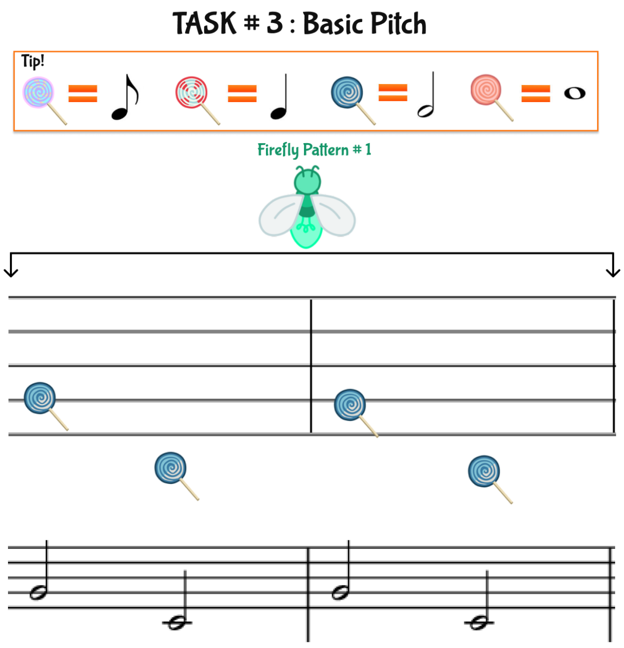


Figure 6.9: Basic pitch tip 1

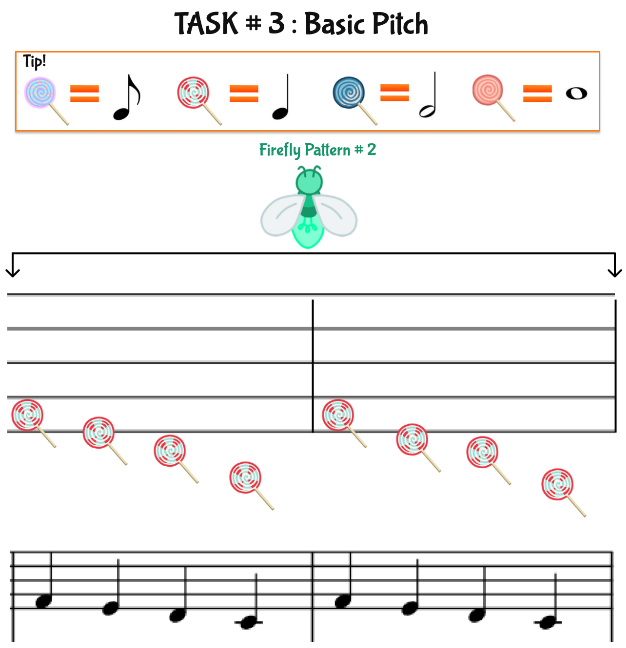


Figure 6.10: Basic pitch tip 2

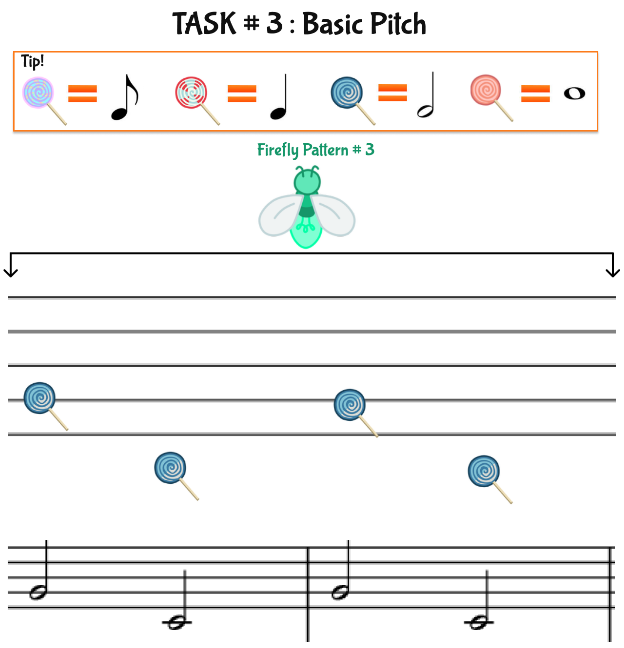


Figure 6.11: Basic pitch tip 3

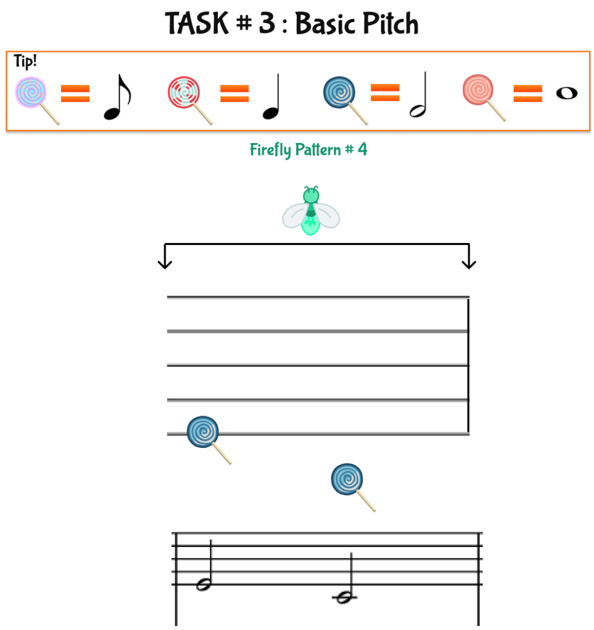


Figure 6.12: Basic pitch tip 4

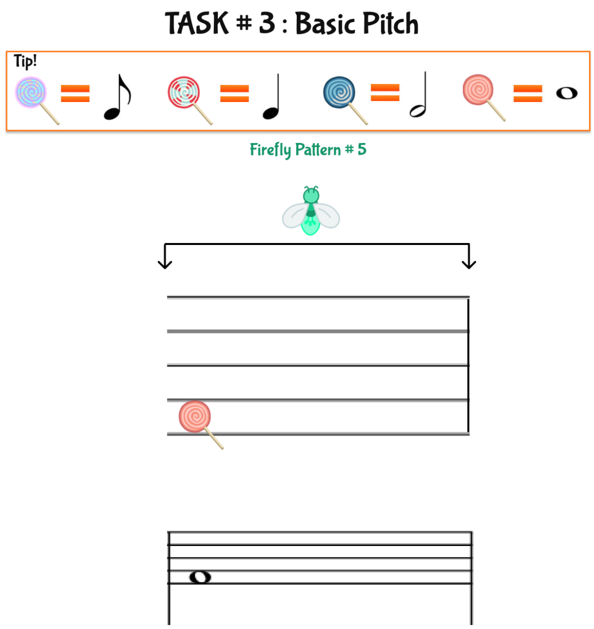


Figure 6.13: Basic pitch tip 5

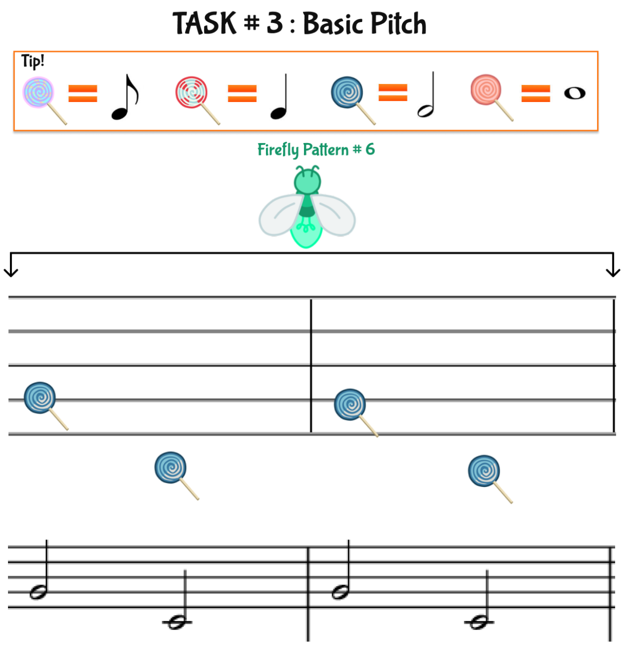


Figure 6.14: Basic pitch tip 6

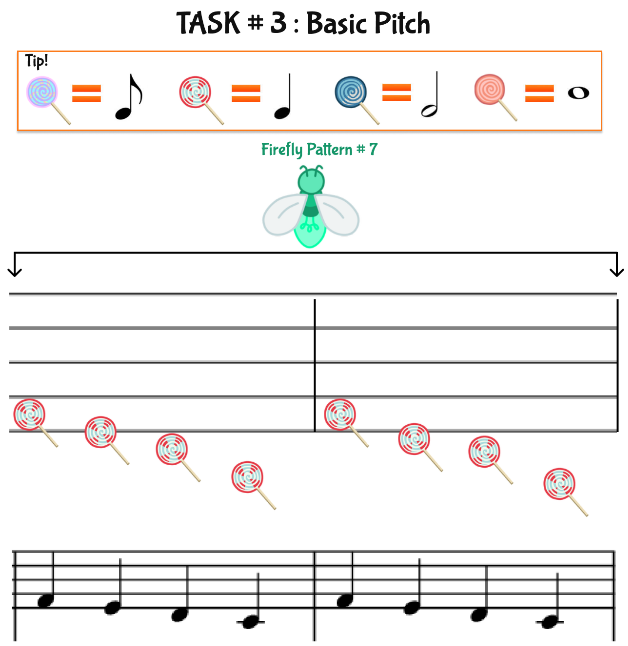


Figure 6.15: Basic pitch tip 7

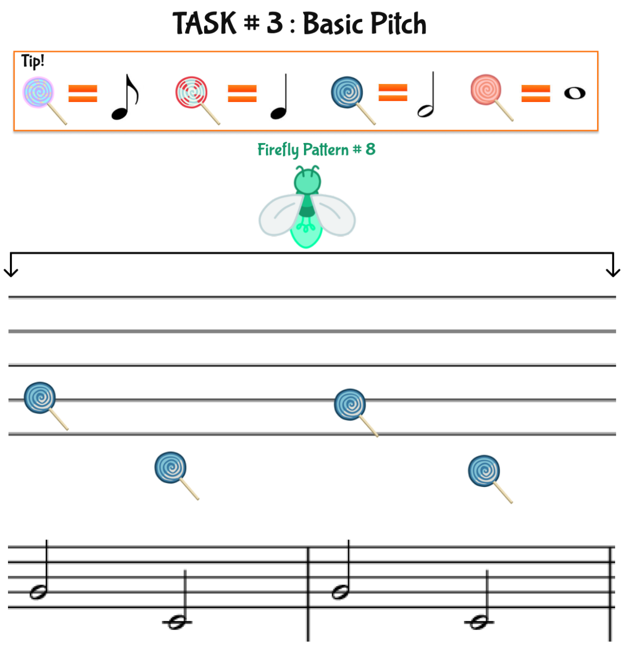


Figure 6.16: Basic pitch tip 8

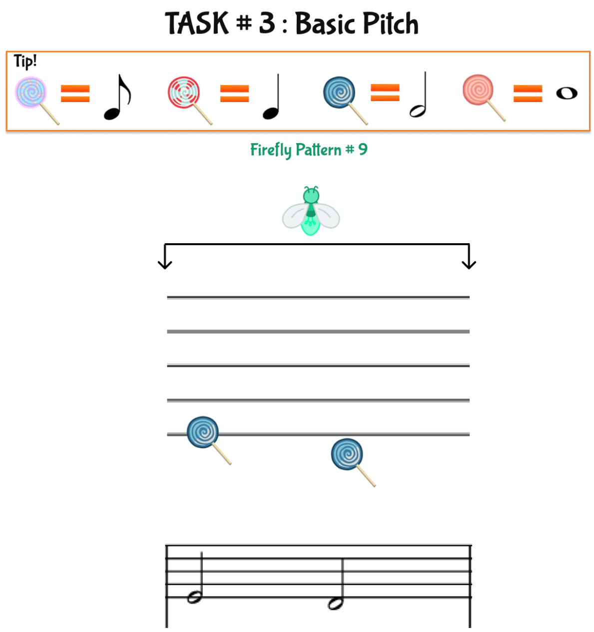


Figure 6.17: Basic pitch tip 9

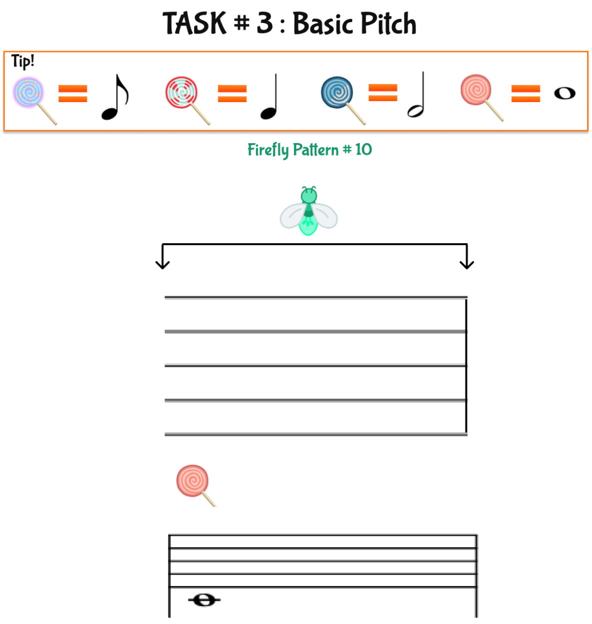


Figure 6.18: Basic pitch tip 10

For the fourth task, the child is asked to recreate a part of the song *"Twinkle Twinkle Little Star"* with a music sheet which could be seen in Figure 6.19, and an audio file that the child could listen to. Compared to task 2 and task 3, task 4 does not have the visual tips and. The child could only refer to the music sheet and the audio file to recreate the song. This task aims to help the child memorize the different music notes, patterns, and pitches. Like in the previous tasks, the guardians is expected to give minimal guidance and assurance to the child throughout the task.

Figure 6.19: Sheet representation for the song Twinkle twinkle little star.

The last task given to the child aims to assess how much of the music elements is memorized by them. In this task, the child is asked to compose a small part of the song *"London Bridge is Falling Down"*. The music sheet for the song could be seen in Figure 6.20. Unlike the previous tasks where the child is provided with music sheets and visual tips, the last task provides only an audio file that the child could listen to. Like in the previous tasks, the guardians is also expected to give minimal guidance and assurance to the child throughout the task.

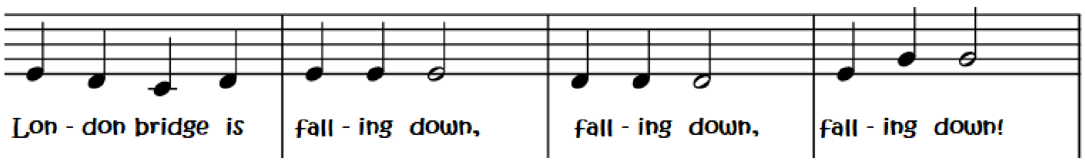


Figure 6.20: Sheet representation for the song London bridge is falling down.

During all of the sessions, the participants were asked to have their video on which all of their parents consented upon. They were also asked verbal consent for recording but participant 1 and participant 5 were not able to consent since they were not accompanied by a guardian during the sessions. We made use of the video and audio recordings to help us collect and observe various findings during the usability tests.

6.2.3 Usability Test Results

Quantitative data such as time completion per task, and number of assistance received by the participant per task were tracked during the sessions. Micro-interactions such as looking at their guardians for approval, asking something to their guardian, and the times the guardians gave assistance to the participant in any way were all recorded and added to get a total amount of assistance received by the participant. The total time taken by each participant per task could be seen in Figure 6.21, and the total assistance received by each participant per task could be seen in Figure 6.22. P1 & P5 did not have a guardian during the sessions which is why they did not receive any kind of assistance while doing their tasks.

Table 6.2: Task completion information among the 5 participants (in seconds)

	T2	T3	T4	T5	x	σ
P1	1472.0	1308.0	1632.0	838.0	1312.5	342.9
P2	1247.0	1294.0	987.0	945.0	1118.3	177.7
P3	560.0	925.0	1260.0	2140.0	1221.3	675.9
P4	482.0	842.0	1750.0	1140.0	1053.5	536.6
P5	972.0	1177.0	1592.0	554.0	1073.8	431.9
$\bar{x}$ T	946.6	1109.2	1444.2	1123.4		
σ T	427.9	214.2	313.7	606.5		

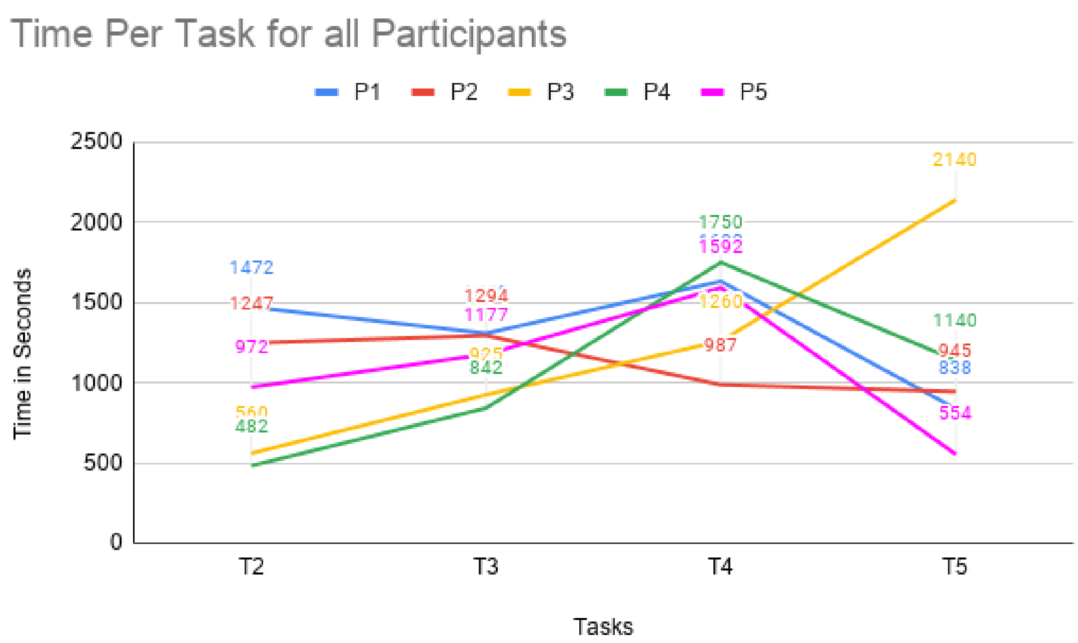


Figure 6.21: Time per task for all participants

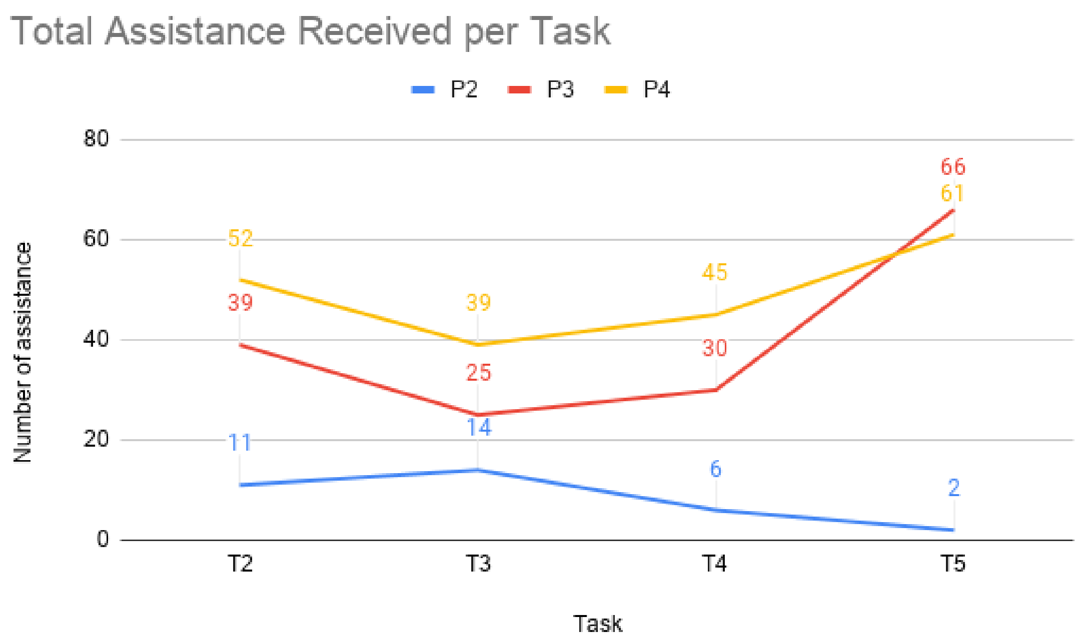


Figure 6.22: Total assistance received per task for all participants

It can be seen in Figure 6.22 that P2 received the least amount of assistance aside from P1 and P5 who received no assistance at all. We believe that children with higher age can do the tasks given to them with minimal assistance while children with lower age tend to rely more on their guardian. This can be said because P2 was able to finish the tasks with minimal assistance especially P1 and P5 with no assistance at all, while P3 and P4 needed a lot of assistance from their guardian.

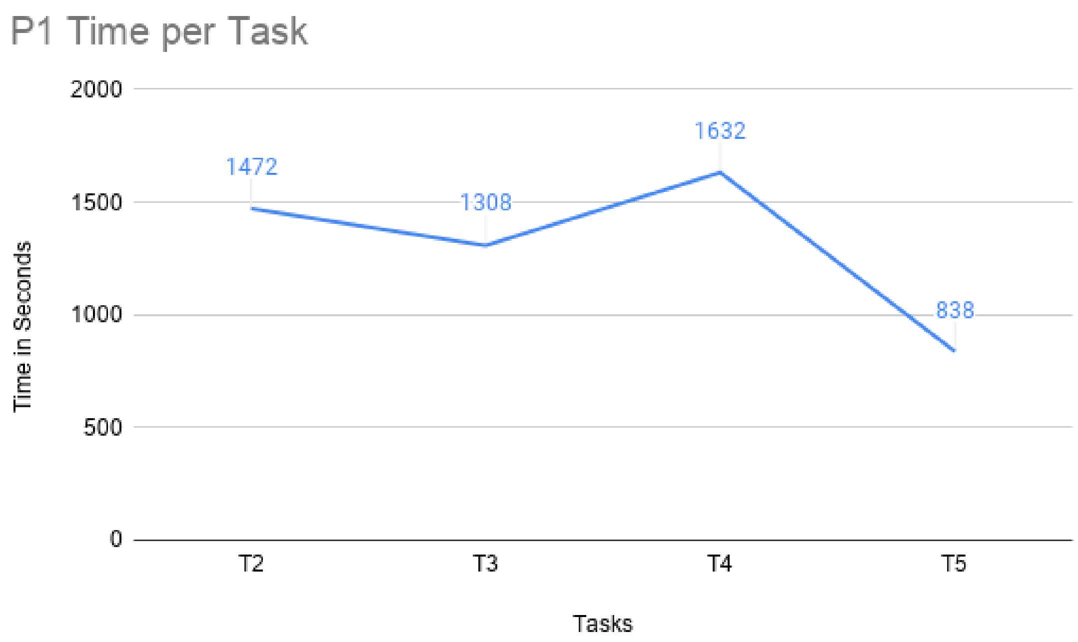


Figure 6.23: Participant 1 time per task

In Figure 6.23, it can be seen that P1 took the longest time in T4 and the shortest time in T5. Based from our observations, P1 had difficulties in trying to compose a song using only a music sheet. This might be because when doing T3 and T2, P1 relied on the visual tips instead of the music sheet. We believe that T5 was too difficult for P1 because even though P1 knows that the output is wrong, P1 still decided to end the task.

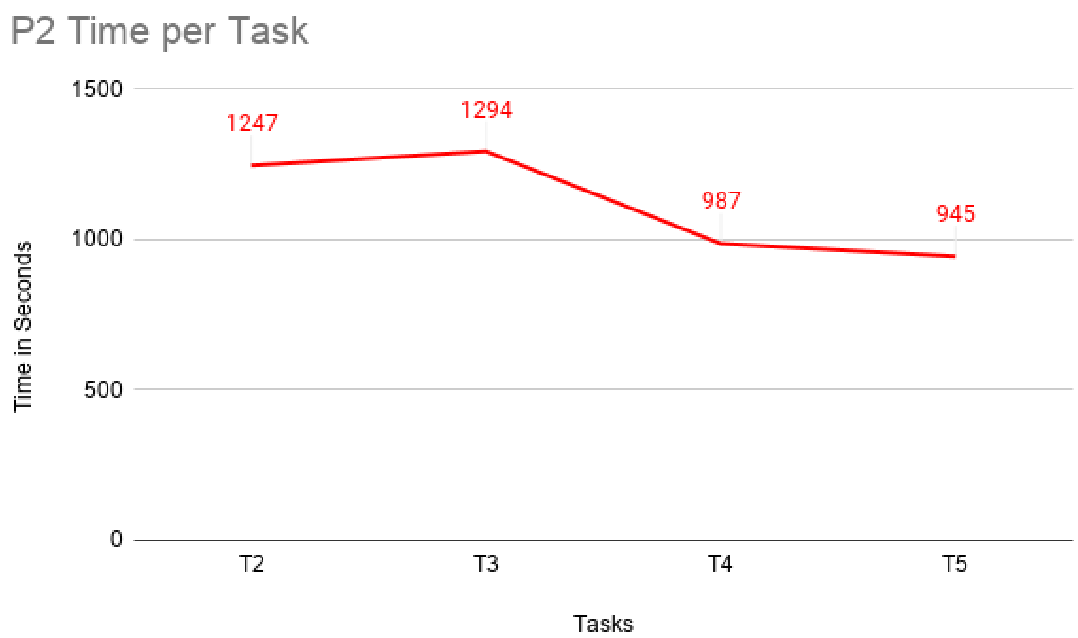


Figure 6.24: Participant 2 time per task

It can be seen in Figure 6.24 that P2 took more time in doing T3 than T2. This might be because P2 was still learning the application during T3. P2 also took less time in doing T4 than T3. We observed that P2 was already familiar with the application and also familiar with how to read a music sheet which might be the reason why P2 finished T4 faster than T3.

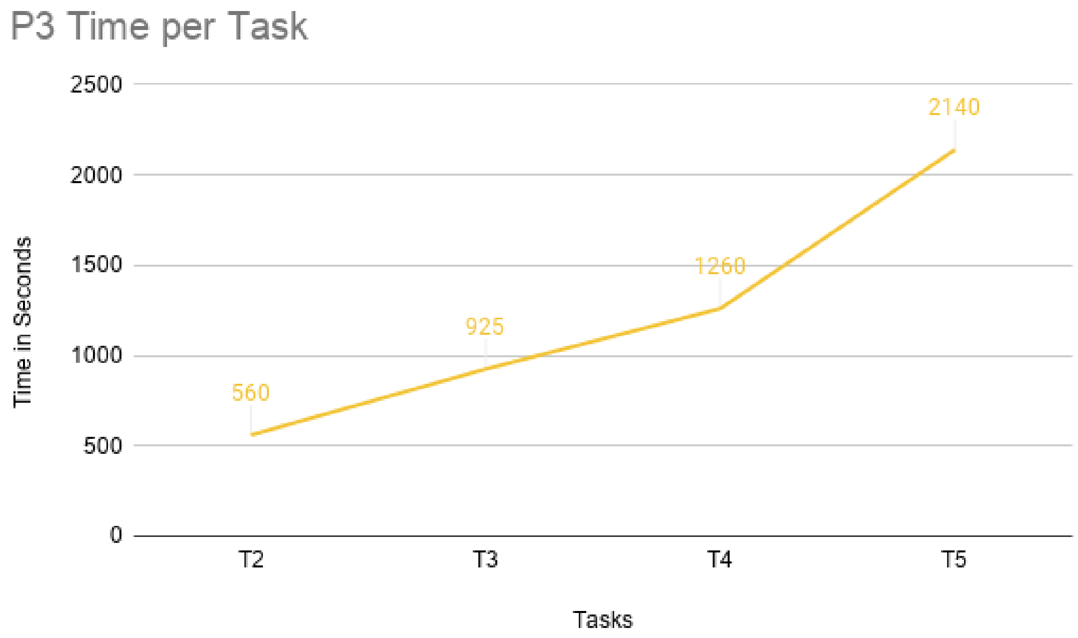


Figure 6.25: Participant 3 time per task

It can be seen in Figure 6.25 that P3 had a faster time time in completing T1, this is because P3 received more assistance compared to P1 and P2. Particularly, P3 had only increasing time in the graph compared to the other participants. It can be seen that P3 was the only one with a time line that has a trend of going up, this is because P3 wanted to be correct so P3 used more time this might be why P3 was the only one to get task 5 correctly.

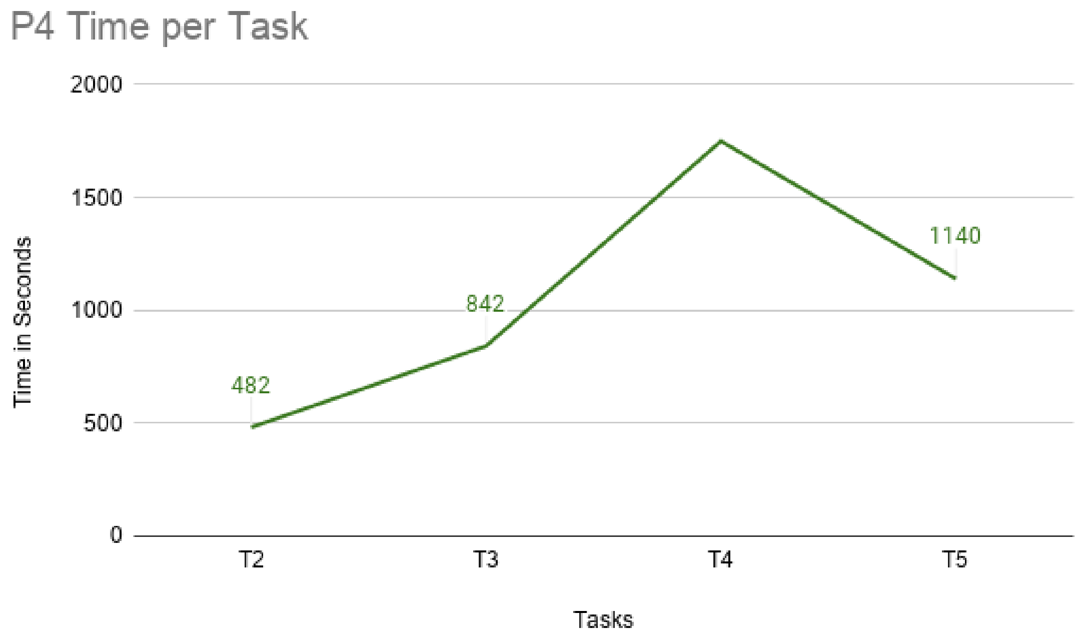


Figure 6.26: Participant 4 time per task

It can be seen in Figure 6.26 similar to P3, P4 had the fastest time in completing T1, this is because P4 received the most assistance compared to the other participants. Due to the assistance received P4 has a harder time in finishing T4 where we encouraged the parents to give no assistance. By T5, P4 was getting more confident in using the application this maybe the reason the time to complete was reduced.

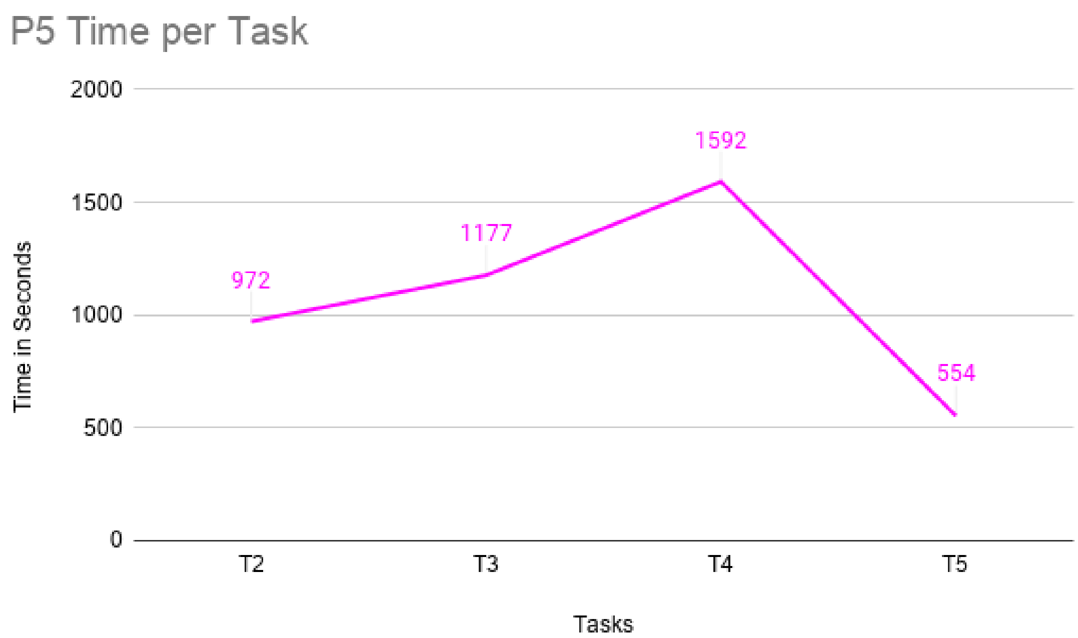


Figure 6.27: Participant 5 time per task

It can be seen in Figure 6.27 that P5 also had a similar trend wherein they have increasing time as they are given harder tasks. The sudden decrease in time for T5 was because P5 decided to give up on finishing T5.

6.3 Post-testing using AttrakDiff

AttrakDiff is an instrument for measuring the attractiveness of interactive products. AttrakDiff makes use of pairs of opposite adjectives that users can choose from to indicate their perception of the product. These adjective-pairs make a collation of the evaluation dimensions possible. In the current version, AttrakDiff is able to measure the perceived pragmatic quality (PQ), perceived hedonic quality-identification (HQ-I), perceived hedonic quality-stimulation (HQ-S), and the attractiveness (ATT) of a product.

Pragmatic quality (PQ) describes the usability of a product and indicates how successfully users are in achieving their goals using the product. Hedonic quality - stimulation (HQ-S) indicates to what extent the product can support the needs of the user in terms of interesting, and stimulating functions, and interaction- and presentation-styles. Hedonic quality - identity (HQ-I) indicates to what extend the product can allow the user to identify with it. Lastly, attractiveness (ATT) describes a global value of the product based on the quality perception.

6.3.1 AttrakDiff Protocol

After the participant has finished the last task, they are asked to answer the AttrakDiff survey. The survey contains 28 different attributes which are categorized into PQ, HQ-S, HQ-I, and ATT. All the attributes are evaluated using a 7-scale method that represent opposites (good-bad). The middle value is 0, left-most value as -3 and right-most value as +3. During the survey, the participants and their guardians might not be familiar with some word pairs. In order to mitigate this, we allotted an extra online meeting to guide them through the words by explaining and giving synonyms that are easier to understand.

6.3.2 AttrakDiff Results

From the data collected, AttrakDiff was able to generate three diagrams. The first one is the portfolio presentation which can be seen in Figure 6.28. The average word pair assessment values for pragmatic and hedonic qualities created a point on the map. The location of the point also showed in which area the point belonged to. The next diagram is the diagram of average values which can be seen in Figure 6.29. In this diagram, the vertical axis represents the average assessment values of the word pairs inside each group and the horizontal axis shows the four word groups (PQ, HQ-I, HQ-S, ATT). The last diagram is a visual representation of the word pair values selected by the children which could be seen in Figure 6.30. This helps us understand their evaluations for the application. Word pairs are in the vertical axis, whereas the assessment is in the horizontal axis. The values in the Figure represent the chosen option in the word pair, -3 referring to the leftmost and 3 to the rightmost part of the scale.

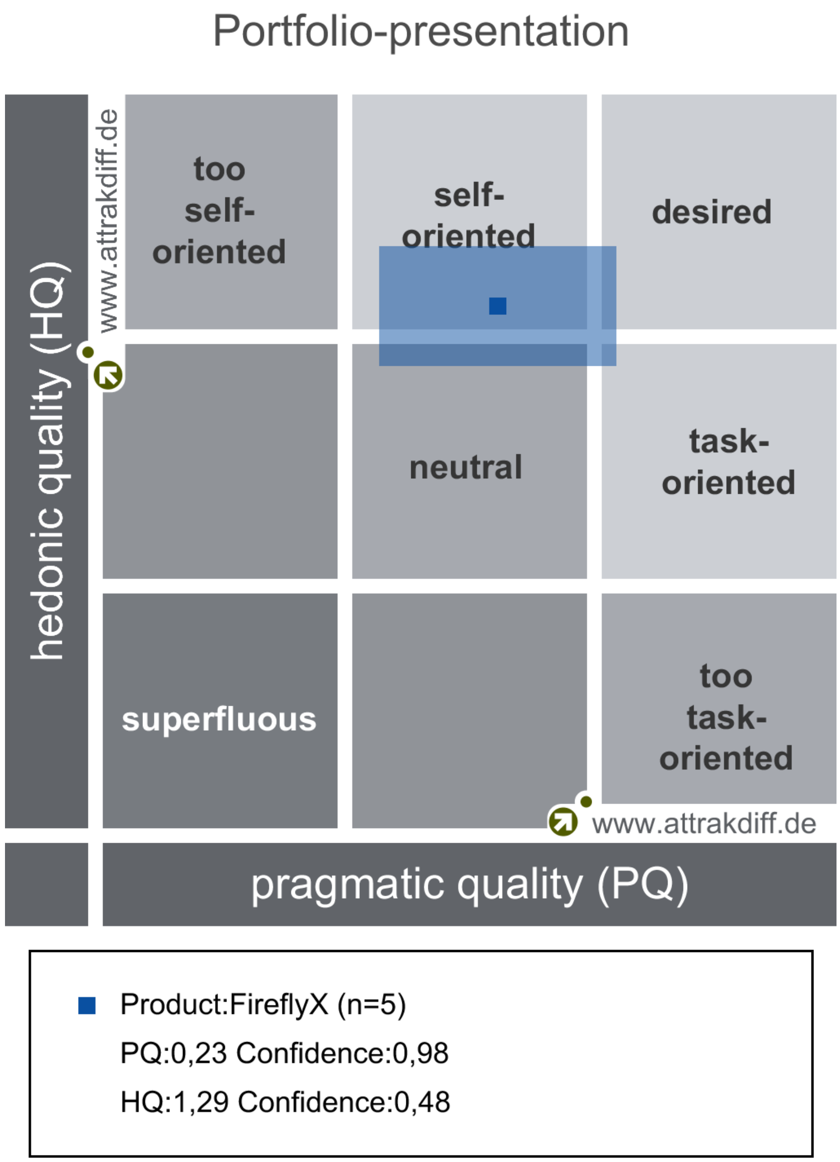


Figure 6.28: Positioning of FireflyX across the multiple dimensions of AttrakDiff

In Figure 6.28 it can be seen that the graph produces a high value for the hedonic qualities and scored a little above average on the pragmatic qualities which indicates that the application has good usability and caters also to the interests of the children. The point on the graph lands on the "self-oriented" part which means features that enable the user to interact with other users are lacking.

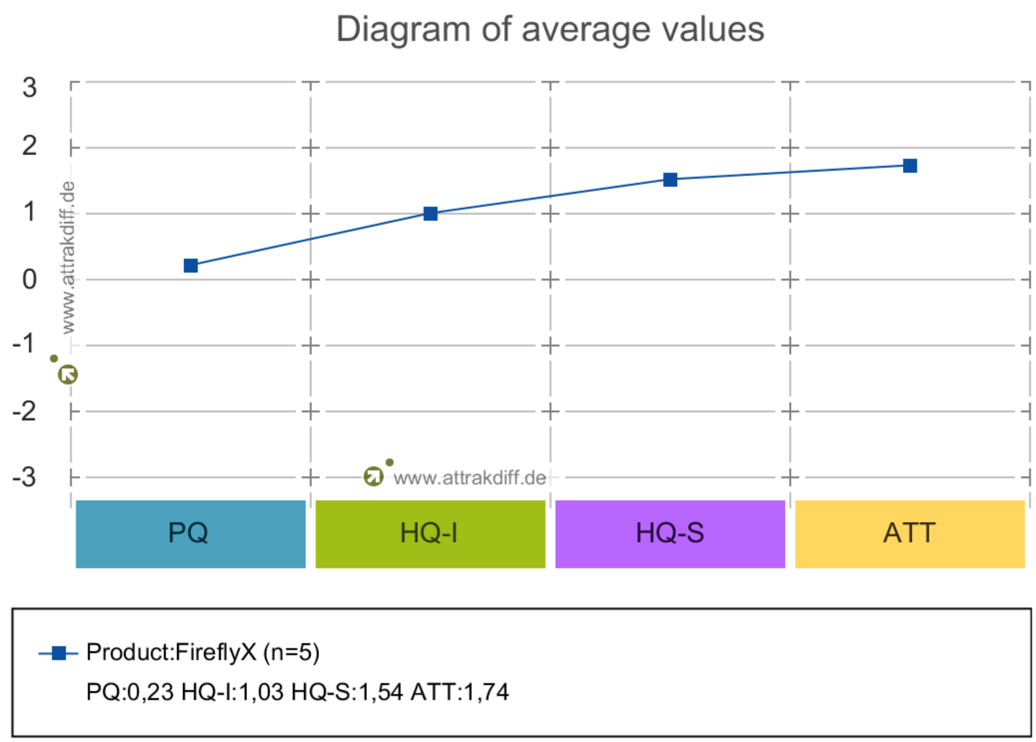


Figure 6.29: Diagram of average values between scores across the dimensions of AttrakDiff (-3 = below average, 0 = neutral/average, 3 = above average)

A bigger number on the y-axis depicts better UX with the didactic content, while a value that approximates to 0 expresses a neutral experience (Giardi, 2019).

It can be seen that all of the values are above 0. This indicates that the score for the usability of the application leans toward the neutral scale. While the hedonic qualities and the overall attractiveness of the application scored 1 and higher which means that the overall design caters to children.

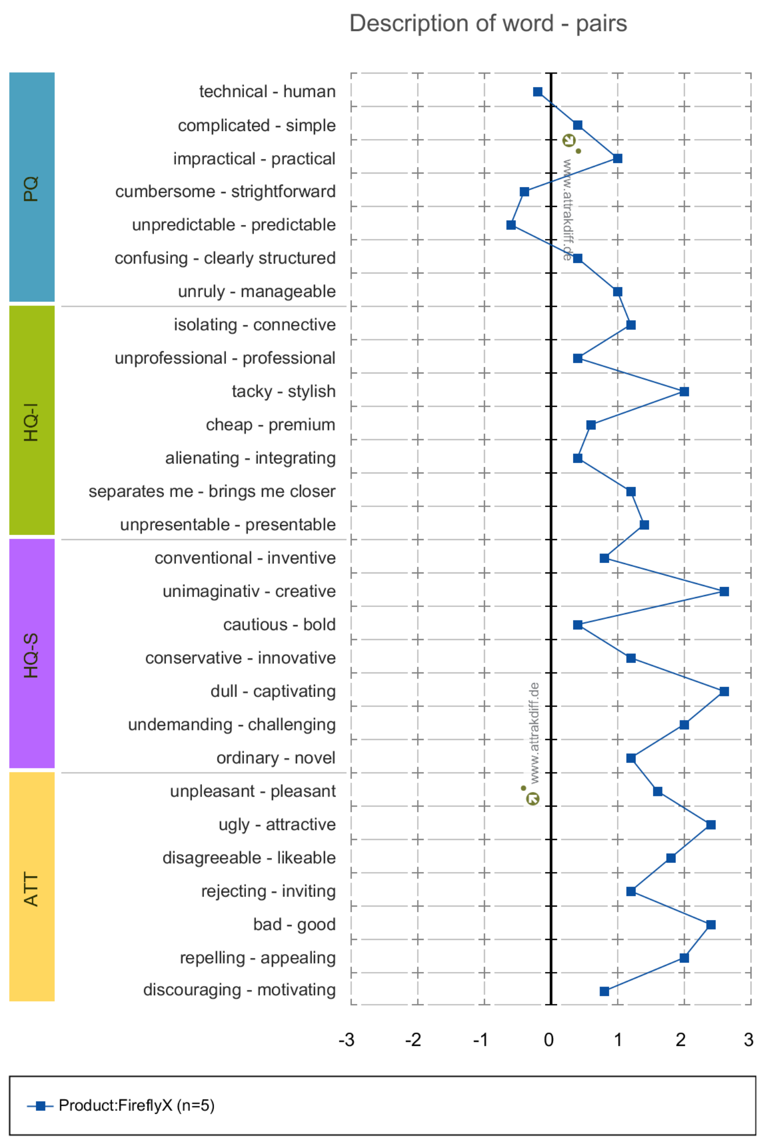


Figure 6.30: Diagram of word pairs generated by AttrakDiff (-3 = below average, 0 = neutral/average, 3 = above average)

Figure 6.30 gives a more descriptive and in-depth answers of the participants. Here, specific values can be seen and what the score is for that word pair. As seen in the figure, words such as stylish, creative, captivating, and attractive were chosen by the participants instead of their counterparts. This is because the participants mentioned during the testing that they liked the design of the application. Words such as technical, cumbersome, and unpredictable were chosen because we observed that most of the participants were confused and had no idea how to use the application at the start.

6.4 Expert Evaluation

6.4.1 Music Expert Criteria and Protocol

A total of three (3) music experts were recruited to participate in our research. As a pre-requisite, they needed to have at least five years of experience with music theory by the time they participated. The demographics of these experts can be seen in Table 6.3.

Characteristic	**Total (n=3)**
Age (mean $\pm SD[range]$)	21.7 $\pm 1.5[20-23]$
Sex (n [%])	
Male	2 [33.3]
Female	1 [66.7]
Years of experience (Mean $\pm SD[range]$)	13 $\pm 1[12-14]$
Specialty (n [%])	
Classical guitar	1 [33.3]
piano	1 [33.3]
Instrumentalist	1 [33.3]

Table 6.3: Music experts demographic

Similar to the testing with the participants, meeting with the music experts in person is also not viable due to the Covid-19 pandemic. This meant that we would have to send them the necessary files online. Because of this, we would also not be able to observe them while they are assessing the outputs of the participants. After the participants finished their tasks, we compiled a Google Drive that contained a profile of each of the participants, their output per task, the expected output per task, and the observations we had per task.

Like the participants, the music experts were also given an orientation about the research, the tasks given to the participants, and what we would ask them to do. After the orientation, we gave them a Google Forms link that contained questions about their demographic, an assessment form for each task, and a input field where they could put their comments and remarks about the output of the participant.

The assessment form is a subset from a music performance adjudication set created by Wrigley and Emmerson (2013). It consists of the criteria pitch, rhythm, tempo, and memory. Each criterion had to be rated on a 7-point Likert scale from needs attention to excellent. Pitch relates to how accurate the pitch of the output is. Rhythm also relates to how accurate the rhythm is. This is the same for tempo, while the memory relates to how the participants remember the music.

6.4.2 Expert Ratings

After the music experts filled out the form, we created five graphs out of the data from the form. The graphs that we were able to make were the sum of an average scores per task of every participants, average pitch scores per task per participant, average rhythm scores per task per participant, average memory scores per task per participant, and average tempo scores per task per participant. We used these results to find trends that would be significant in order for us to find relationships with our qualitative and quantitative data.

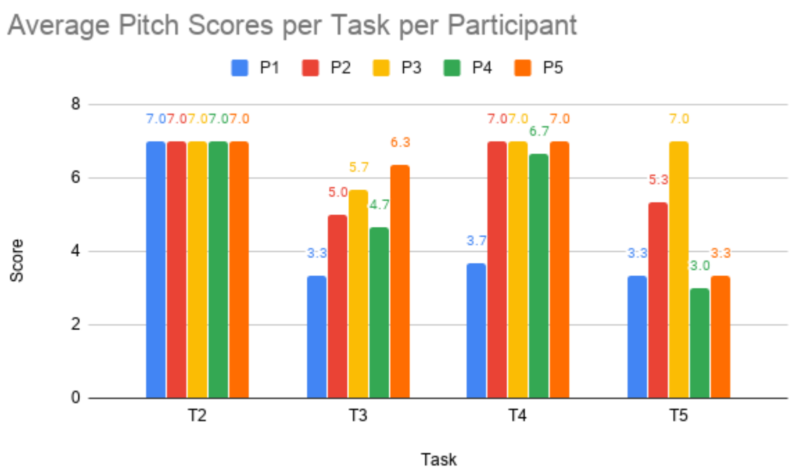


Figure 6.31: Average pitch scores (7 point likert scale) of each participant per task

As seen in Figure 6.31, T2 have equal scores as there is no pitch yet introduced in the task as it focused on the rhythm only. We can see that from T3 to T4 we see a big improvement in the scores of their pitch (using t-test the significance of the change was p = 0.02 check Table 6.4 for values). This may be because they were still learning which notes correspond to the candies. We see a decrease in score from T4 to T5 because we think that they were relying on the music sheet guides in the previous tasks as compared to T5 where there was only an audio of the song as the guide.

Table 6.4: Test of significance between pitch average scores (7 point likert scale) of T3 and T4

P	T3 score	T4 score
P1	3.3	3.7
P2	5.0	7.0
P3	5.7	7.0
P4	4.7	6.7
P5	6.3	7.0
$\bar{x}$	5.0	6.3
σ	1.1	1.4
p-val	0.02	
interpretation	significant	

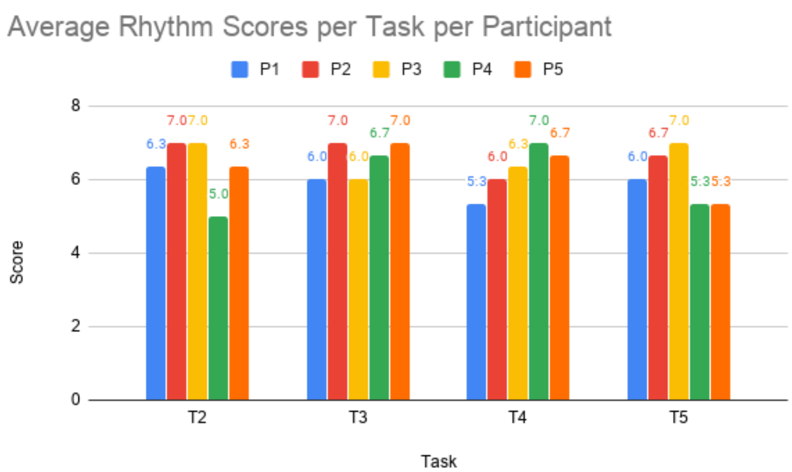


Figure 6.32: Average rhythm scores (7 point likert scale) of each participant per task

As seen in Figure 6.32, the results are similar per task. Though in T5, we can see that P4 and P5 have lower score because they just accepted their mistake and decided to finish the task.

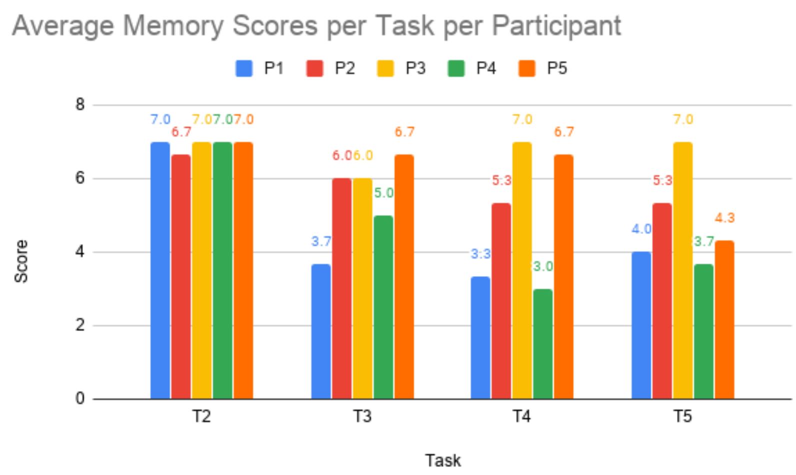


Figure 6.33: Average memory scores (7 point likert scale) of each participant per task

In Figure 6.33, it can be seen that P1 had trouble in T3, T4, and T5 in terms of memory. This is also true for P4 in T4, and T5. This might be because the expected outputs for T4, and T5 is quite different from what they are taught.

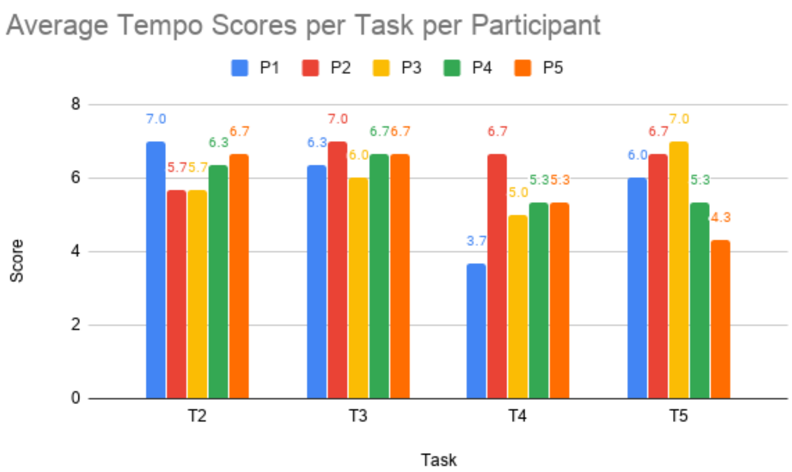


Figure 6.34: Average tempo scores (7 point likert scale) of each participant per task

As seen in Figure 6.34, it can be seen that the results for T2 and T3 are similar because the guides for both tasks included visual diagrams that showed the colors needed for the output. T4 noticeably had lower scores because the guide only included the music sheets and the music playback (Using T-test the significance of the change from T3 to T4 was p = 0.025 check Table 6.5). Notably, one of the comments of our experts mentioned that children tend to choose slower tempos because it was the tempo that was taught to them in their earlier years of childhood.

Table 6.5: Test of significance between average tempo scores (7 point likert scale) on tasks 3 and 4

P	T3 score	T4 score
P1	6.3	3.7
P2	7.0	6.7
P3	6.0	5.0
P4	6.7	5.3
P5	6.7	5.3
$\bar{x}$	6.5	5.2
σ	0.39	1.07
p-val	0.025	
interpretation	significant	

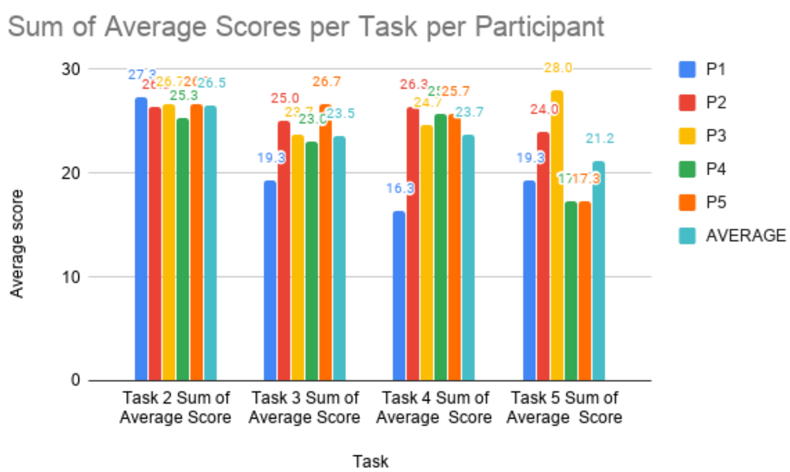


Figure 6.35: Sum of averages of each participant per task (Maximum sum of score is 28)

It can be seen in Figure 6.35 that the participants scored high in T2. Since T2 aims to teach rhythm to the participants, only rhythm scores and tempo scores are emphasized. It is also notable that P1, P4, and P5 scored relatively low because they settled for a wrong composition, while P2 and P3 did their best to ensure that what they composed were correct. Most of the participants had decreased score on T5 because the task had no other guides aside from the music playback.

6.5 Analysis of Data

We used Pearson's correlation coefficient *r-val* to determine if there is a possible between correlation between pairs of scores that we have collected from our AttrakDiff test, usability test, and qualitative analyses (Hauke & Kossowski, 2011). We looked at values and trends presented in the previous sections to determine if there is strong or moderate positive or negative correlation between these two factors. These will help us later in the discussion of the findings and human factors associated with the usage of FireflyX.

Table 6.6: Correlation between age and assist counts

P	age	assist count
P1	7.0	0.0
P2	8.0	33.0
P3	6.0	160.0
P4	6.0	197.0
P5	8.0	0.0
$\bar{x}$	7.0	78.0
σ	1.0	93.6
r-val	-0.9	
interpretation	strong negative correlation	

Table 6.7: Correlation between Task 4 and 5 music expert scores using all four categories (Maximum sum of score is 28) and Task 4 and 5 Time

P	scores	time in seconds
P1 T4	16.3	1632.0
P2 T4	26.3	987.0
P3 T4	24.7	1260.0
P4 T4	25.7	1750.0
P5 T4	25.7	1592.0
P1 T5	23.7	838.0
P2 T5	19.3	945.0
P3 T5	24.0	2140.0
P4 T5	28.0	1140.0
P5 T5	17.3	554.0
$\bar{x}$	23.1	1283.8
σ	4.0	485.6
r-val	0.5	
interpretation	moderate positive correlation	

Table 6.8: Correlation between Task 5 music expert scores using all four categories (Maximum sum of score is 28) and Task 5 Time

P	T5 time in seconds	T5 average scores
P1	838.0	19.3
P2	945.0	24.0
P3	2140.0	28.0
P4	1140.0	17.3
P5	554.0	17.3
$\bar{x}$	1123.4	21.2
σ	606.5	4.7
r-val	0.8	
interpretation	strong positive correlation	

Table 6.9: Correlation between task time in seconds (t) and count of assists (ac)

P	T2 t	T2 ac	T3 t	T3 ac	T4 t	T4 ac	T5 t	T5 ac
P1	1472.0	0.0	1308.0	0.0	1632.0	0.0	838.0	0.0
P2	1247.0	11.0.0	1294.0	14.0	987.0	6.0	945.0	2.0
P3	560.0	39.0	925.0	25.0	1260	30.0	2140.0	66.0
P4	482.0	52.0	842.0	39.0	1750.0	45.0	1140.0	61.0
P5	972.0	0.0	1177.0	0.0	1592.0	0.0	554.0	0.0
$\bar{x}$	946.6	20.4	1109.2	15.6	1444.2	16.2	1123.4	25.8
σ	427.9	23.8	214.2	16.8	313.7	20.3	606.5	34.5
r -val	-0.9		-0.9		0.2		0.8	
interpretation	strong negative correlation		strong negative correlation		weak positive correlation		strong positive correlation	

De La Salle University

Chapter 7

Human Factors in using FireflyX

Through our user study, we performed analysis on both qualitative and quantitative data. These qualitative data include participant utterances during think out aloud protocol, coded observations during usability tests, comments submitted with test instruments and others. These qualitative data were analyzed with the quantitative data in order to be able to bridge findings and statistics. Quantitative data includes AttrakDiff scores, time it took to complete tasks, expert rating scores, and other measures.

7.0.1 Behavioral Findings

We were able to observe findings that describe how children behave and act while using our mobile application. These behaviors go from subtle cues all the way to mannerisms that are obvious during the usability tests.

Nodding of head while listening to firefly. We were able to observe that certain participants listen and move with the sound output of the firefly models in the mobile app. P1, P2, and P3 were the most obvious in demonstrating these traits. They began by listening to the tune and then nodding or moving their heads along in sync with the tune as they listen to the sound output. This happened while they were trying to verify the fireflies that they have created. We then believe that this nodding behavior aids in memory as first introduced by de Souza et al. (2018) where the researcher also mentioned that a child nodding his head confirms a yes showing a positive kind of response.

Figure 7.1: Participant nodding head while listening to playback

In Figure 7.1, we can see that the the participant is nodding his head as he listens to the playback of the iPad.

Eagerness, playfulness and confidence. In using FireflyX, we observed that 4 out of 5 participants (P1, P2, P4, and P5) would tend to tap the tablet and nearby surfaces more frequently. They would *overtap* (when they are supposed to tap an element once, but instead would tap it more times that they are supposed to). This appears to be like a display of eager behavior towards exploring the application more. We believe that this is due to the sandbox nature of the application which encourages playful behaviour. This gives the children the feeling as if they were immersed in an actual sandbox while using the application (Inal & Cagiltay, 2007). The participants also exhibited elevated or increased levels of happiness as seen in their energetic display when they confirm that they did their tasks correctly. Whenever they would listen to their outputs and hear that it matches the expected output, they tend to clap and exhibit energetic behavior out of sheer excitement. The participants also showed to have an improved mood (which means it is a positive feeling) when they receive feedback on their tasks (that they did it right). Notably, P4 exhibited laughter even when they committed technical mistakes (e.g. notes are off-pitch) during their tasks. We believe that accomplishing tasks can help uplift the mood of the child and give them a boost in their morale. The study by Elahi et al. (2017) also mentioned that when the child feels validated and is reassured, they feel more motivated to use the application. They also begin to show signs of increased confidence the longer they use the FireflyX. Comments like "ez [easy]" and moments when participants asserted that they are finished with the task (even if they are only being asked) were observed as they use the application. We believe that children become more confident in using the application if they spend more time using it. As Frøkjær et al. (2000) states, the time spent in using a system indicates that there is learning, and this will eventually enable them to learn to do their tasks more efficiently. Our data supports this as we observed a moderate positive correlation as seen in Table 6.7 with the scores and the time of tasks 4 and 5 *(r-val = 0.5)*. Indicating that as the participants take their time (averaging 1444.2 and 1123.4 seconds respectively) in completing the task the higher rating (averaging a score of 23.7 and 21.2 over 28 respectively) they get from the music experts. We chose task 4 and task 5 because this is the stage where they are encouraged to play around and explore with the application with minimal guidance in order to finish the task.

Figure 7.2: Participant tapping the back of an iPad

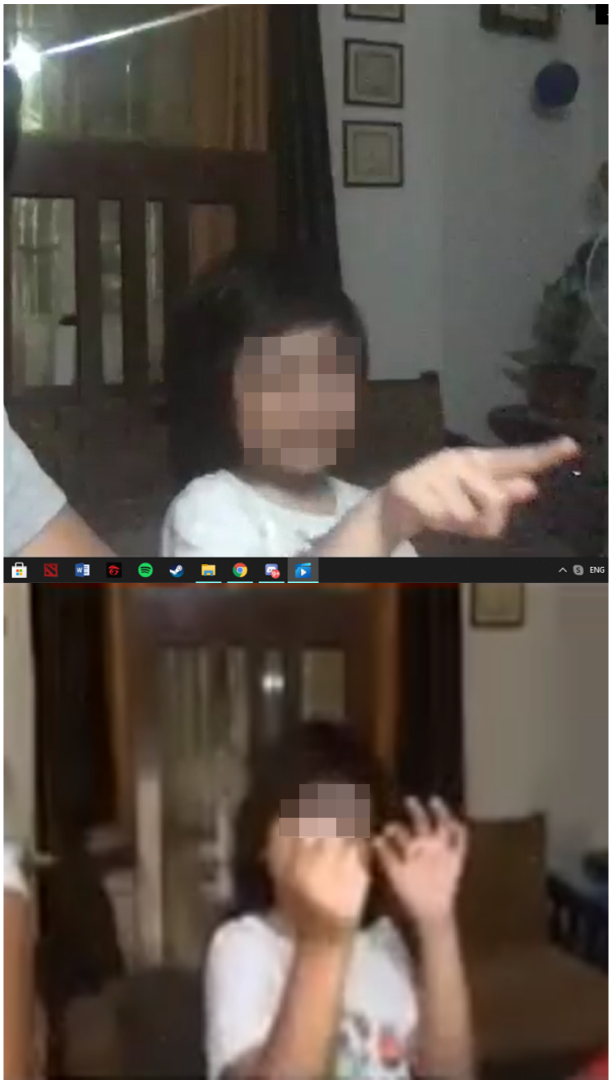


Figure 7.3: Participant playing with fingers

In Figure 7.2, we can see that the the participant is playfully tapping and fidgeting the back of the iPad while doing the task. Same as Figure 7.3, the participant is also playing with their fingers while using the application.

Annoyance, committing mistakes and seeking validation. We also observed that some participants are more easily-annoyed and become more scared than others. These were more commonly-observed from P1 and P2 when they are trying to complete their tasks and commit mistakes along the way. They get frustrated and annoyed when making mistakes or when they do not figure out what is wrong with what they are doing. These were more common while they were doing tasks 4 and 5. This can be verified in the results of the Attrakdiff survey. The word pair *Undemanding-Challenging* leaned more towards challenging (HQ-S: 5-7 points). We believe this is because tasks 4 and 5 were designed to be more difficult than the other tasks (which are more exploratory in nature). These were further observed in specific instances where they said *"is there a time limit?"*, and *"I am not sure"*. These comments describe as if the participants were afraid to commit mistakes and are conscious of their output. We believe that children are afraid committing mistakes, as seen as well in the study by Hourcade (2015). Their work integrated the social aspect of committing mistakes and doing tasks in familiar scenarios. Children tend to copy how adults act and sometimes would do things similar to the way they see from their guardians. While the children would only notice how the adults would successfully do their tasks, they would not notice the mistakes made along the way as they might not realize or know that was wrong. Participants P3 and P4 were observed to constantly refer to their guardian as they progress through their tasks. They do this to check if they are on track which can be interpreted as a social behavior that seeks validation. In Figure 6.22, we observed a strong negative correlation as seen in Table 6.6 with the number of times they referred to their guardians for help and to their respective age *(r-val = -0.9)*. Indicating that as the participants age decrease they would tend to ask for more assistance from their guardian.

7.0.2 Attention Findings

We observed specific behaviors that describe how children pay attention when using FireflyX. These findings can describe how the thinking out loud and visual elements help them in learning music.

Retaining memory by thinking out loud. We observed that there was a difference in how the participants made use of the available reference while they do their tasks. P1 and P4 were more reliant to the candy diagrams (as supplementary materials to help them read the music sheets) as compared to P2, P3, and P5. In task 4, the candy diagrams were intentionally replaced with actual music sheets. P1 and P4 made obvious reactions to this subtle change. The other participants (P2, P3 and P5) showed that they were fine with using them. Based on their demographic information as seen in Table 6.1, P2, P3, and P5 were more knowledgeable in music compared to the other participants. We also noticed that P2, P3, and P5 used the music sheets more confidently and were exhibiting the thinking out loud protocol more. We believe that this aids in memorability as previously-studied by Gagne and Smith Jr (1962). They found that there is a memory advantage in thinking out loud or saying the words compared to keeping it to yourself in your head. Interestingly, P2, P3, and P5 had a mean average of $x = 6.3$ for their rating in memory while P1 and P4 had mean average of $x = 4.6$ which supports the idea that thinking out loud helps with retaining information.

Convenient visual matching through playful cues. One important finding that strengthens the design of our application was observed when we got comments pertaining to the visual elements of the application that participants liked. The children were able to easily-connect the firefly model and their corresponding musical rudiments. The participants were also able to easily-grasp the concept represented by the candy diagrams. These can be seen in the results of the Attrakdiff tests. The scores were leaning towards the Stylish, Creative and Appealing criteria based on the hedonistic qualities in the form (HQ-S and ATT scores were between 5 and 7). This indicates that the participants really liked the how the visual elements are portrayed and how it helped them understand the musical rudiments. The design helped in attracting and motivating the children to keep using the application. This was also seen in the studies by (Cohen et al., 2011; Burton & Pearsall, 2016; Chung & Wu, 2017) which all explicitly mentioned the importance of having a child-friendly design helps children become motivated in using the app. This also helped catch and maintain their attention which helped them in having an increased pace in learning.

7.0.3 Learning Findings

We observed specific behaviors that describe how children learned and used FireflyX. These findings can describe their attitude and preference towards learning and difficult content.

An accessible visual reference to aid music learning. We developed and deployed a project website[1] to serve as an all around guide for participants and experts. However, the website seemed to be of more use in the completion of their tasks, than what was originally-intended. All participants used the website during the majority of their tasks. They used the site to refer to the patterns that they wish to copy from it. Interestingly, P2 and P3 were relying less on the site as they were more used to the application (mention their higher score from expert once the evaluation forms is finalized). Having a guide were able to help the participants learn the application and the concepts sooner (Pashler et al., 2007). Making the guides clearer and arranging them in an organized way helps stimulate learning thereby making it easier for them to copy; little by little getting used to learning a particular topic. With the help of the guide, they learned to use the application and started memorizing the notes that corresponds to the candies. All participants were observed to have improved in remembering what the buttons do, and in turn, they navigated through the application faster as the sessions go by. We believe that if children get used to a specific layout and

[1] https://comet.dlsu.edu.ph/FireflyX/

the more time they spend using it, they instinctively press the buttons that they need given the task (Wiedenbeck, 1999; Ibharim & Yatim, 2014). These studies mention that when the elements are designed well and are understandable by the child in a glance, they will tend to learn to use the application faster.

Ignoring their obvious mistakes. Some participants tend to deliberately ignore their mistakes while they validate their output through the audio playback feature. Even after they preview a specific sound or tone and notice that there was an obvious error, they still decided to push with that firefly configuration. We believe that this is because some participants may want to finish the task for the sake of finishing. This was very prevalent in task 5 which intentionally was a difficult challenge to begin with. The completion times for T5 averaged 1073.75 seconds and the expert ratings were around 21.2/28. We observed a strong positive correlation as seen in Table 6.8 the time spent in task 5 and their scores *(r-val = 0.8)*. Indicating that as the participants spend more time in doing task 5 their scores tend to increase.

Findings on Handedness. Four (4) participants were recorded to be right-handed. Interestingly, two of these right-handed participants (namely P3, P4) used their non-dominant hand (left) in performing majority of their tasks. This is not the case for P1 and P5, who are right-handed and also used their dominant hand for their tasks. For the case of P4 (RH, M, 7), this was because of the current test setup where his tablet was placed on the left side of the laptop. He used his left hand more in performing his tasks, while he used his right hand to operate the laptop (in order to specifically look at the pitch and rhythms in the site). P3 (RH, F, 6) showed cross-handedness (formerly called mixed-handedness in the literature) in performing the tasks. She would switch between hands to select element in the screen depending on which was closer to that hand. The sole left-handed participant, P2 (M, 8) demonstrated behaviour similar to that of P3. He was mixed-handed as well like P3.

Unsupervised learning vs intended guided learning for children. Participants exhibited trial and error as they used the application. As they made more trials and revisions, they tend to re-calibrate and fine-tune the pitches and patterns they compose with the fireflies. They repeatedly did this until they were somewhat satisfied with their work. This was observed across all five (5) participants and all their tasks especially on tasks 3 and 4. With regards to task 5, even though participants ignored their mistakes as stated in the previous section, they still managed to explore until they actually grew tired of their tasks. This allowed the children to reflect their own mistakes without being given the answer by the application (unsupervised). As we are using a sandbox environment, this enabled the participants to explore several possible outcomes until they produce a relatively-satisfying output.

Chapter 8

Conclusion and Future Work

8.1 Summary

In this study, we were able to understand how children were taught music concepts like tempo, rhythm, pitch, and notes by their music teachers. We were able to get their insights and converted them into artifacts that guided us in developing the application. This is in line with the first objective which is to identify the activities music teachers implement when teaching music patterns to children. We were then able to design and develop across several iterations the different features of the application. This was done to satisfy our second specific objective which is to identify the features that could enable playful interactions when teaching children music. Also, through our user studies we were able to observe the applications usability through the children's outputs. The usability of the application was also evaluated using AttrakDiff as well as the scores given by the music expert evaluations based on the quality of the outputs given by the children. Lastly, we were able to discover specific human factors or behaviours such as *Nodding of head while listening to firefly*, *Convenient visual matching through playful cues*, *Ignoring* *their obvious mistakes*, and others that children exhibit when they are using our application for learning music. This satisfies our third objective which is to identify the human factors that children exhibit while using FireflyX. These three specific objectives then helped us in achieving our general objective of modeling the human factors that the children exhibited when using the mobile musical application as we were able to categorize then synthesize them in different findings like *Behaviour*, *Attention*, and *Learning*.

The application was iteratively developed. Usability testing of the application was done along with using AttrakDiff. A high fidelity prototype was initially designed using Figma. It consisted of images that depicted how the application would look like at different points. Users could also press on screen flows and hot spots that simulate the behaviour of FireflyX. We were then able to develop an initial prototype based from the mockup. Iterative testing commenced where users were asked to do specific tasks. This was done in order to examine the usability of the application. Based from the testing from the previous iterations, major changes such as changing the cookies into candies, removing the sun and moon, and reducing the amount of patterns to five (5) were recommended. A third iteration of testing using this version of the application focused on teaching children musical rudiments such as rhythm, tempo, and pitch. The outputs of the children were also graded by three music experts.

Based from the AttrakDiff results, the application shows that is has good usability and that it caters to the interests of the children. From the same tests, the overall attractiveness of the application seems to entertain the children users as well. Although words such as technical, cumbersome, and unpredictable appeared in the results, over all the application still performed relatively better than expected.

8.2 Recommendations

For future work, the authors believe that there is a need to perform these tests involving more participants and music experts. This will give us a broader understanding on the music learning of the children, the rating of experts and the human factors per se. We also recommend to test the application in a face-to-face environment as we believe more observations about the participants could be gathered than the virtual setup. This way, it will be easier for both the researchers and the participants to perform the tests. Since the current application only provides learning for an individual child, a collaborative feature can be introduced so that children can help their learning as a group by either configuring the fireflies together or sharing their firefly configurations while using the application.

Future work that relate to the scope of the application can explore expanding the notes, such as dotted notations, that the users can choose from. Other music rudiments such as harmony, timbre, and texture could be added to the application. These additions could broaden the scope of the application and might introduce curiosity to the users. Furthermore, by giving users more options and combinations to choose from, these could take advantage of the playfulness of children which would make them play more with the application.

References

Andre, A. (2010). Otomushi: touching sound. In *Acm siggraph asia 2010 sketches* (p. 33).

Aqda, M. F., Hamidi, F., & Rahimi, M. (2011). The comparative effect of computer-aided instruction and traditional teaching on students creativity in math classes. *Procedia Computer Science*, *3*, 266–270.

Arnold, D. N. (1997). Computer-aided instruction. *Encarta encyclopedia. New Mexico: Microsoft*.

Aziz, N. A. A. (2013). Childrens interaction with tablet applications: Gestures and interface design. *Children*, *2*(3), 447–450.

Baecker, R. M. (2014). *Readings in human-computer interaction: toward the year 2000*. Elsevier.

Bellamy, R., John, B., & Kogan, S. (2011). Deploying cogtool: integrating quantitative usability assessment into real-world software development. In *Proceedings of the 33rd international conference on software engineering* (pp. 691–700).

Bennett, S. (1976). The process of musical creation: Interviews with eight composers. *Journal of research in music education*, *24*(1), 3–13.

Blair-Early, A., & Zender, M. (2008). User interface design principles for interaction design. *Design Issues*, *24*(3), 85–107.

Bläsing, T., Batyuk, L., Schmidt, A.-D., Camtepe, S. A., & Albayrak, S. (2010). An android application sandbox system for suspicious software detection. In

2010 5th international conference on malicious and unwanted software (pp. 55–62).

Bos, B., Wilder, L., Cook, M., & O'Donnell, R. (2014). Learning mathematics through minecraft. *Teaching Children Mathematics*, *21*(1), 56–59.

Burrows, T. (1999). *How to read music: reading music made simple*. Macmillan.

Burton, S. L., & Pearsall, A. (2016). Music-based ipad app preferences of young children. *Research Studies in Music Education*, *38*(1), 75–91.

Byrd, D. (2009). Studying music is difficult and important: Challenges of music knowledge representation. In *Dagstuhl seminar proceedings.*

Chan, K. G., Deja, J. A., Tobias, J. P., Gonzales, A. V., & Dancel, M. A. (2019). Applying user-centered techniques in the design of a usable mobile musical composition tool. In *Proceedings of the 5th international acm in-cooperation hci and ux conference* (pp. 152–159).

Chapman, C. (2018, Mar). *Exploring the gestalt principles of design.* Toptal. Retrieved from `https://www.toptal.com/designers/ui/gestalt-principles-of-design`

Christmann, E. P., & Badgett, J. L. (2000). The comparative effectiveness of cai on collegiate academic performance. *Journal of Computing in Higher Education*, *11*(2), 91–103.

Chung, S.-M., & Wu, C.-T. (2017). Designing music games and mobile apps for early music learning. In *Serious games and edutainment applications* (pp. 57–75). Springer.

Cohen, M., Hadley, M., & Frank, M. (2011). Young children, apps & ipad. *US Department of Education Ready to Learn Program*, *200*, 5–10.

Collins, D. (2005). A synthesis process model of creative thinking in music composition. *Psychology of music*, *33*(2), 193–216.

Crowell, C., Mora-Guiard, J., & Pares, N. (2018). The role of context in defining play. In *Proceedings of the 2018 annual symposium on computer-human interaction in play companion extended abstracts* (pp. 407–413).

Czaja, S. J., & Lee, C. C. (2007). The impact of aging on access to technology. *Universal Access in the Information Society*, *5*(4), 341.

Dalgarno, B., & Lee, M. J. (2010). What are the learning affordances of 3-d virtual environments? *British Journal of Educational Technology*, *41*(1), 10–32.

Dannenberg, R. B. (1997). Machine tongues xix: Nyquist, a language for composition and sound synthesis. *Computer Music Journal*, *21*(3), 50–60.

Davison, B. K., & Walker, B. N. (2007). Sonification sandbox reconstruction: Software standard for auditory graphs..

Deka, B., Huang, Z., Franzen, C., Hibschman, J., Afergan, D., Li, Y., . . . Kumar, R. (2017). Rico: A mobile app dataset for building data-driven design applications. In *Proceedings of the 30th annual acm symposium on user interface software and technology* (pp. 845–854).

de Souza, G. N., de Deus, D. F., Tadaiesky, V., de Araújo, I. M., Monteiro, D. C., & de Santana, Á. L. (2018). Optimizing tasks generation for children in the early stages of literacy teaching: a study using bio-inspired metaheuristics. *Soft Computing*, *22*(20), 6811–6824.

Dix, A. (2009). *Human-computer interaction.* Springer.

Dix, A., Finlay, J., Abowd, G., & Beale, R. (2004, 01). Human-computer interaction..

EducationalAppStore. (2015). *Sesame street makes music review.* Educational App Store. Retrieved from `https://www.educationalappstore.com/app/sesame-street-makes-music`

EducationalAppStore. (2017). *Mussila music school review.* Educational App Store. Retrieved from `https://www.educationalappstore.com/app/mussila-music-school`

Elahi, M. T., Korayem, A. H., Shariati, A., Meghdari, A., Alemi, M., Ahmadi, E., . . . Heidari, R. (2017). xylotism: A tablet-based application to teach music to children with autism. In *International conference on social robotics* (pp. 728–738).

Erol, O., & Kurt, A. A. (2017). The effects of teaching programming with scratch on pre-service information technology teachers' motivation and achievement. *Computers in Human Behavior*, *77*, 11–18.

Estrella, E. (2019). *4 common clefs often used in music.* Retrieved from `https://www.liveabout.com/commonly-used-types-of-clefs-2455921` (Accessed: 2019-10-24)

Foley, J. D., Wallace, V. L., & Chan, P. (1984). The human factors of computer graphics interaction techniques. *IEEE computer Graphics and Applications*, *4*(11), 13–48.

Frøkjær, E., Hertzum, M., & Hornbæk, K. (2000). Measuring usability: are effectiveness, efficiency, and satisfaction really correlated? In *Proceedings of the sigchi conference on human factors in computing systems* (pp. 345–352).

Gagne, R. M., & Smith Jr, E. C. (1962). A study of the effects of verbalization on problem solving. *Journal of experimental psychology*, *63*(1), 12.

Gardner, H. (1971). Children's duplication of rhythmic patterns. *Journal of Research in Music Education*, *19*(3), 355–360.

Ghazali, G. M., & Alam, S. (2005). In the minds of children: Understanding motivation to learn music..

Giardi, A. (2019). Evaluate childrens user experience with attrakdiff method: Usiena experience. *Form@ re-Open Journal per la formazione in rete*, *19*(3), 155–174.

Goldberg, I., Wagner, D., Thomas, R., Brewer, E. A., et al. (1996). A secure environment for untrusted helper applications: Confining the wily hacker. In *Proceedings of the 6th conference on usenix security symposium, focusing on applications of cryptography* (Vol. 6, pp. 1–1).

Gong, J., Tarasewich, P., et al. (2004). Guidelines for handheld mobile device interface design. In *Proceedings of dsi 2004 annual meeting* (pp. 3751–3756).

Gray, S. I., Campbell, S., Cater, K., Bevan, C., & Gilchrist, I. (2018). Designing games for vision screening: Lessons learned from observing preschool video game play. In *Proceedings of the 2018 annual symposium on computer-human interaction in play companion extended abstracts* (pp. 439–445).

Hasan, H. S., & Kareem, S. A. (2012). Human computer interaction for vision based hand gesture recognition: a survey. In *2012 international conference on advanced computer science applications and technologies (acsat)* (pp. 55–60).

Hauke, J., & Kossowski, T. (2011). Comparison of values of pearson's and spearman's correlation coefficients on the same sets of data. *Quaestiones geo-*

graphicae, *30*(2), 87–93.
Hobbs, C. (2015). *Rhythmic values and compound metre.* Retrieved from https://musictheorysite.wordpress.com/2015/06/page/2/ (Accessed: 2019-12-14)
Hourcade, J. P. (2015). Child-computer interaction. *Self, Iowa City, Iowa*.
Hourcade, J. P., Bullock-Rest, N. E., & Hansen, T. E. (2012). Multitouch tablet applications and activities to enhance the social skills of children with autism spectrum disorders. *Personal and ubiquitous computing*, *16*(2), 157–168.
Hourcade, J. P., et al. (2008). Interaction design and children. *Foundations and Trends® in Human–Computer Interaction*, *1*(4), 277–392.
Ibharim, L. F. M., & Yatim, M. H. M. (2014). ibuat: Paper prototyping of interactive game design authoring tool for children. In *International conference on serious games development and applications* (pp. 82–92).
Inal, Y., & Cagiltay, K. (2007). Flow experiences of children in an interactive social game environment. *British Journal of Educational Technology*, *38*(3), 455–464.
Ince, C. (2019). *Programming for music: Explorations in abstraction* (Unpublished doctoral dissertation). University of Huddersfield.
John Wiley & Sons, I. (2019). *Musical punctuation: Bar lines and measures.* Retrieved from https://www.dummies.com/art-center/music/piano/musical-punctuation-bar-lines-and-measures/ (Accessed: 2010-10-24)
Jørgensen, M. H., Knudsen, A. S., Wilmot, T. M., Lund, K. D., Serafin, S., & Purwins, H. (2015). A mobile music museum experience for children. In *Nime* (pp. 36–37).
Kalelioğlu, F., & Gülbahar, Y. (2014). The effects of teaching programming via scratch on problem solving skills: A discussion from learners' perspective. *Informatics in Education*, *13*(1).
Kaptelinin, V. (1996). Activity theory: Implications for human-computer interaction. *Context and consciousness: Activity theory and human-computer interaction*, *1*, 103–116.
Kimball, M. A. (2013). Visual design principles: An empirical study of design

lore. *Journal of Technical Writing and Communication*, *43*(1), 3–41.

Levinowitz, L. M. (1999). The importance of music in early childhood. *Music Educators Journal*, *86*(1), 17.

Li, Z. (2018). Understanding the design of playful experiences around ingestible sensors. In *Proceedings of the 2018 annual symposium on computer-human interaction in play companion extended abstracts* (pp. 33–38).

Loy, G., & Abbott, C. (1985). Programming languages for computer music synthesis, performance, and composition. *ACM Computing Surveys (CSUR)*, *17*(2), 235–265.

MacKenzie, I. S. (1992). Fitts' law as a research and design tool in human-computer interaction. *Human-computer interaction*, *7*(1), 91–139.

MacKenzie, I. S., & Buxton, W. (1992). Extending fitts' law to two-dimensional tasks. In *Proceedings of the sigchi conference on human factors in computing systems* (pp. 219–226).

Maloney, J., Resnick, M., Rusk, N., Silverman, B., & Eastmond, E. (2010). The scratch programming language and environment. *ACM Transactions on Computing Education (TOCE)*, *10*(4), 16.

Markopoulos, P., & Bekker, M. (2003). Interaction design and children. *Interacting with computers*, *15*(2), 141–149.

Martin, C. L., Fabes, R. A., Evans, S. M., & Wyman, H. (1999). Social cognition on the playground: Children's beliefs about playing with girls versus boys and their relations to sex segregated play. *Journal of Social and Personal Relationships*, *16*(6), 751–771.

May, B. N. (2013). Public school early childhood music education: Challenges and solutions. *General Music Today*, *27*(1), 40–44.

McIntire, J. M. (2007). Developing literacy through music. *Teaching Music*, *15*(1), 44.

McPherson, G. E. (2015). *The child as musician: A handbook of musical development.* Oxford University Press.

Miller, G. (1956). " the magical number seven, plus or minus two." psychological review 63.

Miller, M. (2005). *The complete idiot's guide to music theory.* Penguin.

Mortensen, D. (2019, Sep). *Natural user interfaces what are they and how do you design user interfaces that feel natural?* Retrieved from https://www.interaction-design.org/literature/article/natural-user-interfaces-what-are-they-and-how-do-you-design-user-interfaces-that-feel-natural

Myers, B. A. (1998). A brief history of human computer interaction technology. *interactions*, *5*(2), 44–54.

Nelson, R., & Christensen, C. (2009). *Foundations of music.* Cengage Learning, Inc.

Nielsen, J. (1994). Enhancing the explanatory power of usability heuristics. In *Proceedings of the sigchi conference on human factors in computing systems* (pp. 152–158).

Nielsen, J. (2013). *10 usability heuristics for user interface design.* Retrieved from https://www.designprinciplesftw.com/collections/10-usability-heuristics-for-user-interface-design

Nielsen, J., & Molich, R. (1990). Heuristic evaluation of user interfaces. In *Proceedings of the sigchi conference on human factors in computing systems* (pp. 249–256).

Nilsson, E. G. (2009). Design patterns for user interface for mobile applications. *Advances in engineering software*, *40*(12), 1318–1328.

Nodalo, G., Santiago III, J. M., Valenzuela, J., & Deja, J. A. (2016). On building design guidelines for an interactive machine learning sandbox application.

Norman, D. A. (1999). Affordance, conventions, and design. *interactions*, *6*(3), 38–43.

Oosterholt, R., Kusano, M., & de Vries, G. (1996). Interaction design and human factors support in the development of a personal communicator for children. In *Proceedings of the sigchi conference on human factors in computing systems* (pp. 450–457).

Ouahbi, I., Kaddari, F., Darhmaoui, H., Elachqar, A., & Lahmine, S. (2015). Learning basic programming concepts by creating games with scratch programming environment. *Procedia-Social and Behavioral Sciences*, *191*, 1479–1482.

Papadakis, S., & Kalogiannakis, M. (2017). Mobile educational applications for children: what educators and parents need to know. *International Journal of Mobile Learning and Organisation*, *11*(3), 256–277.

Pashler, H., Bain, P. M., Bottge, B. A., Graesser, A., Koedinger, K., McDaniel, M., & Metcalfe, J. (2007). Organizing instruction and study to improve student learning. ies practice guide. ncer 2007-2004. *National Center for Education Research*.

Paule-Ruiz, M., Álvarez-García, V., Pérez-Pérez, J. R., Álvarez-Sierra, M., & Trespalacios-Menéndez, F. (2017). Music learning in preschool with mobile devices. *Behaviour & Information Technology*, *36*(1), 95–111.

Pennycook, B. W. (1985). Computer-music interfaces: a survey. *ACM Computing Surveys (CSUR)*, *17*(2), 267–289.

Preece, J., Rogers, Y., & Sharp, H. (2015). *Interaction design: Beyond human-computer interaction* (4th ed.). Hoboken, NJ: Wiley.

Prevelakis, V., & Spinellis, D. (2001). Sandboxing applications. In *Usenix annual technical conference, freenix track* (pp. 119–126).

Putnam, A. L. (2015). Mnemonics in education: Current research and applications. *Translational Issues in Psychological Science*, *1*(2), 130.

Radu, I. (2014). Augmented reality in education: a meta-review and cross-media analysis. *Personal and Ubiquitous Computing*, *18*(6), 1533–1543.

Rautaray, S. S., & Agrawal, A. (2015). Vision based hand gesture recognition for human computer interaction: a survey. *Artificial intelligence review*, *43*(1), 1–54.

Read, G. (1964). *Music notation: a manual of modern practice* (Tech. Rep.).

Read, J. C., & Bekker, M. M. (2011). The nature of child computer interaction. In *Proceedings of the 25th bcs conference on human-computer interaction* (pp. 163–170).

Rekimoto, J. (2002). Smartskin: an infrastructure for freehand manipulation on interactive surfaces. In *Proceedings of the sigchi conference on human factors in computing systems* (pp. 113–120).

Riso, C. (2016). *Basic music theory - 1st post - notes, rests, and note particulars.* Retrieved from `http://cathyriso.blogspot.com/2016/08/basic-music`

-theory-1st-post.html (Accessed: 2019-10-24)

Rivadelo, R. F. (1986). *Fundamentals of music.* National Book Store.

Roschelle, J. M., Pea, R. D., Hoadley, C. M., Gordin, D. N., & Means, B. M. (2000). Changing how and what children learn in school with computer-based technologies. *The future of children*, 76–101.

Rose, T. (2014). *Reading music lesson 34: Time signature.* Retrieved from http://www.musicreadingsavant.com/reading-music-lesson-34-time-signature/ (Accessed: 2010-10-24)

Roth, W.-M. (2001). Gestures: Their role in teaching and learning. *Review of educational research*, *71*(3), 365–392.

Ruiz, J., Li, Y., & Lank, E. (2011). User-defined motion gestures for mobile interaction. In *Proceedings of the sigchi conference on human factors in computing systems* (pp. 197–206).

Salvendy, G. (2012). *Handbook of human factors and ergonomics.* John Wiley & Sons.

Scheepmaker, L., Frauenberger, C., & Spiel, K. (2018). The things we play with roles of technology in social play. In *Proceedings of the 2018 annual symposium on computer-human interaction in play* (pp. 451–462).

Self, J. A. (1974). Student models in computer-aided instruction. *International Journal of Man-machine studies*, *6*(2), 261–276.

Stephanidis, C. (2012). The encyclopedia of human-computer interaction. *The encyclopedia of human-computer interaction*.

Strommen, E. (1998). When the interface is a talking dinosaur: learning across media with actimates barney. In *Chi* (Vol. 98, pp. 288–295).

Taheri, A., Meghdari, A., Alemi, M., Pouretemad, H., Poorgoldooz, P., & Roohbakhsh, M. (2016). Social robots and teaching music to autistic children: Myth or reality? In *International conference on social robotics* (pp. 541–550).

Tidwell, J. (2010). *Designing interfaces: Patterns for effective interaction design.* " O'Reilly Media, Inc.".

Tong, J. (2016). Design and implementation of music teaching platform in college based on android mobile technology. *International Journal of Emerging*

Technologies in Learning (iJET), *11*(05), 4–9.

Turetsky, D. (1984). *Lisp: a gentle introduction to symbolic computation.* Harper & Row Publishers, Inc.

Walker, B. N., & Cothran, J. T. (2003). Sonification sandbox: A graphical toolkit for auditory graphs. In *Proceedings of the 9th international conference on auditory display (icad).*

Wiedenbeck, S. (1999). The use of icons and labels in an end user application program: an empirical study of learning and retention. *Behaviour & Information Technology*, *18*(2), 68–82.

Williams, R. (2015). *The non-designer's design book: Design and typographic principles for the visual novice.* Pearson Education.

Willoughby, D. (1971). Comprehensive musicianship and undergraduate music curricula..

Wrigley, W. J., & Emmerson, S. B. (2013). Ecological development and validation of a music performance rating scale for five instrument families. *Psychology of Music*, *41*(1), 97–118.

Yee, K.-P. (2002). User interaction design for secure systems. In *International conference on information and communications security* (pp. 278–290).

Zaranis, N., Kalogiannakis, M., & Papadakis, S. (2013). Using mobile devices for teaching realistic mathematics in kindergarten education. *Creative Education*, *4*(7), 1–10.

Zhou, Y., Percival, G., Wang, X., Wang, Y., & Zhao, S. (2011). Mogclass: evaluation of a collaborative system of mobile devices for classroom music education of young children. In *proceedings of the sigchi conference on human factors in computing systems* (pp. 523–532).

Appendix A

Research Ethics Documents

RESEARCH ETHICS CLEARANCE FORM For Thesis Proposals[1]	
Names of student researcher/s :	ATO, Paolo Miguel B. GAMUTAN, Mart Henrick A. SALCEDO, Antoine Mikhael M. VALENCIA, Josh Cezar L.
College:	College of Computer Studies
Department:	Software Technology Department
Research Title:	FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children
Course:	BS Computer Science with specialization in Software Technology
Expected duration of project:	from: May 2019 to: August 2020

Ethical considerations

Access to the school will be requested from the school administration
Parental consent form will be given to parents to receive permission to request participation from their children for observation and testing.
Children will be observed
Music Teacher will be interviewed
Music Expert will be interviewed
Music teacher will be asked to assess the usability of the prototype
Music teacher will be asked to assess the usability of the final app

To the best of our knowledge, the ethical issues listed above have been addressed in the research.

DEJA, Jordan Aiko P.
Name and signature of adviser/mentor
Date: 11/06/2019

CARONONGAN, Arturo III
Name and signature of panelist
Date: 12/16/19

FERNANDEZ, Ryan Austin
Name and signature of panelist
Date:

[1]The same form can be used for the reports of completed projects. The appropriate heading need only be used.

Scanned by CamScanner

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2(D) Version No.: 1 Version Date: July 2016

DE LA SALLE UNIVERSITY
General Research Ethics Checklist

This checklist is to ensure that the research conducted by the faculty members and students of De La Salle University is carried out according to the guiding principles outlined in the Code of Research Ethics of the University. The investigator is advised to refer to the <u>De La Salle University Code of Research Ethics and Guide to Responsible Conduct of Research</u> before completing this checklist. Statements pertinent to ethical issues in research should be addressed below. The checklist will help the researcher/s and advisers/readers/evaluators determine whether procedures should be undertaken during the course of the research to maintain ethical standards. The University's <u>Guide to the Responsible Conduct of Research</u> provides details on these appropriate procedures.

Researcher Details	
Students	ATO, Paolo Miguel B. GAMUTAN, Mart Henrick A. SALCEDO, Antoine Mikhael M. VALENCIA, Josh Cezar L.
Thesis Adviser	DEJA, Jordan Aiko P.
Department/College	Software Technology Department/ College of Computer Studies
Proposed Title of the Research	FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children
Term(s) and academic year in which research project is to be undertaken	3rd Term A.Y. 2018-2019 1st Term A.Y. 2019-2020 2nd Term A.Y. 2019-2020 3rd Term A.Y. 2019-2020

This checklist must be completed AFTER the **De La Salle University Code of Ethics** ***has been read and BEFORE gathering data.***

Questions	Yes	No
1. Does your research involve human participants (this includes new data gathered or using pre-existing data)? If your answer is **yes**, please answer **Checklist A (Human Participants).** **Please specify if the kind of research you will be conducting falls under any of the following Human Participants sub-categories:**	✔	

De La Salle University

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2(D) Version No.: 1 Version Date: July 2016

1.A. Will you be conducting Action Research in an existing business, company, or school? If your answer is **yes**, please answer **Checklist F (Action Research).**	✔	
1.B. Does your research involve online communities (this includes culling data from social media platforms, online forums and blogs)? If your answer is **yes**, please answer **Checklist G (Internet Research).**		✔
1.C. Does your research involve human participants who are situated in a community and may necessitate permission to acquire access to them? If your answer is **yes**, please answer **Checklist H (Community Research).**		✔
2. Will your research make use of documents which are not in the public domain and, thus, require permission for use from the custodian of such documents? **If YES, please provide certification that permission from the custodian of the data was sought and granted.**		✔
3. Will your research make use of secondary data (e.g., surveys, inventories, plans, official documents, etc.) from an institution, organization, or agency, which are not in the public domain and, thus, require permission for use from the custodian of such documents? **If YES, please provide certification that permission to use the data was sought from the institution, organization, or agency and approval was granted.**		✔
4. Does your research involve animals (non-human subjects)? If your answer is **yes**, please answer **Checklist B (Animal Subjects).**		✔
5. Does your research involve Wildlife? If your answer is **yes**, please answer **Checklist C (Wildlife)**.		✔
6. Does your research involve microorganisms that are infectious, disease causing or harmful to health? If your answer is **yes**, please answer **Checklist D (Infectious Agents).**		✔
7. Does your research involve toxic/chemicals/ substances/materials? If your answer is **yes**, please answer **Checklist E (Toxic Agents).**		✔

Research with Ethical Issues to address:

If you have a YES answer to any of the above categories, you will be required to complete a detailed checklist for that particular category. A YES answer does not mean the disapproval of your research proposal. By providing you with a more detailed checklist, we ensure that the ethical concerns are identified so these can be addressed in adherence to the University Code of Ethics.

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2(D) Version No.: 1 Version Date: July 2016

Declaration of Conflict of Interest

[✔] 1. I do not have a conflict of interest in any form (personal, financial, proprietary, or professional) with the sponsor/grant-giving organization, the study, the co-investigators/personnel, or the site.

[ ] 2. I do have a conflict of interest, specifically:

[ ] A. I have a personal/family or professional interest in the results of the study (family members who are co-proponents or personnel in the study, membership in relevant professional associations/organizations).
Please describe the personal/family or professional interest:

[ ] B. I have propriety interest vested in this proposal (with the intent to apply for a patent, trademark, copyright, or license)
Please describe propriety interest:

[ ] C. I have significant financial interest vested in this proposal (remuneration that exceeds P250,000.00 each year or equity interest in the form of stock, stock options or other ownership interests).
Please describe financial interest:

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2.03 Version No.: 1 Effectivity Date: July 2016

DE LA SALLE UNIVERSITY

Checklist A
Research Ethics Checklist for Investigations involving Human Participants

***This checklist must be completed AFTER the* De La Salle University Code of Research Ethics and Guide to Responsible Conduct of Research *has been read* and *BEFORE gathering data. The University Code of Research Ethics is available at* http://www.dlsu.edu.ph/offices/urco/forms/URCO-Code-of-Research-Ethics_August2011.pdf**

NOTE: This checklist is completed after the research proponent fills out the General Checklist Form.

Only answer this Checklist if you answered YES on question 1 of the General Checklist.

Researcher Details	
Students	ATO, Paolo Miguel B. GAMUTAN, Mart Henrick A. SALCEDO, Antoine Mikhael M. VALENCIA, Josh Cezar L.
Thesis Adviser	DEJA, Jordan Aiko P.
Department/College	Software Technology Department/ College of Computer Studies
Proposed Title of the Research	FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children
Term(s) and academic year in which research project is to be undertaken	3rd Term A.Y. 2018-2019 1st Term A.Y. 2019-2020 2nd Term A.Y. 2019-2020 3rd Term A.Y. 2019-2020

The research goal is to identify and model the human factors and behaviours that children exhibit when given the task of learning how to compose music with a mobile musical tool. Children aged 5-8 will be observed in order to gather data. We will also be interviewing music teachers to get insights on how children in these ages learn music and to ask how they teach their students. In testing, the children will then be asked to use the application while being recorded via camera. This will be done through 3 iterations while further improving the application by using the data through each step.

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2.03 Version No.: 1 Effectivity Date: July 2016

The following should be attached to the checklist:

- A copy of the informed consent form to be used in the study.
- A copy of the instrument/tool that will be administered to the participants.
- If applicable, a copy of the letter seeking permission to collect data from participants who are under the supervision of an agency, institution, department, or office.
- If applicable, a copy of the parental consent form for participants below 18 years old.

The following items refer to important ethical considerations in the conduct of research with human participants. Provide a check for the appropriate answer to each question.

Source of data *Please check all that apply:*		
✔	**1. New data will be collected from human participants** If you checked this item, how will the new data be gathered? Please check all that apply. **After answering this question, please proceed to page 3**	
	✔	**Experimental Procedures/Intervention/ Treatments**
		Focus Group
	✔	**Personal Interviews**
	✔	**Self-administered Questionnaire**
	✔	**Researcher-administered Questionnaire**
		Internet survey
	✔	**Observation**
		Telephone survey
		Others, please specify:
	2. Pre-existing data from human participants, i.e., from a dataset **If you checked this item, please proceed to page 7**	

options are checked (both new data and pre-existing data), **answer all of the questions in this document.**

Only answer if new data will be collected (item 1 above)	
Sampling Details	
Number of Participants/Subjects	**3**
Location where the participants will be recruited/ where subjects will be obtained?	**Music Schools from Metro Manila**

De La Salle University

De La Salle University	**Research Ethics Review Committee** **Research Ethics Office, 3F Henry Sy Sr. Hall** **De La Salle University Manila** **2401 Taft Avenue, Manila 1004, Philippines** **REO@dlsu.edu.ph (632) 524-4611 loc. 513**	SOP No.: 2 Form No.: 2.03 Version No.: 1 Effectivity Date: July 2016

How long will the data collection take place?	**1 - 2 hours**
Who will perform the data collection?	**The Researchers**
Location(s) where data collection will take place	**Music Schools from Metro Manila**
What procedures will be employed to ensure voluntary consent from participants?	**The parents of the participants will be given an informed consent form.** **The participants will be given a consent form.** **The participants can review the consent form before and after signing.** **The participants are encouraged to ask questions before, and during the experiment.** **The participants will be given compensation for participating.** **The participant is allowed to withdraw at any time of the experiment.**
Data Retention	
How long will data with participant identifiers be kept after the publication of the first paper from the project?	**N/A**
How long will anonymized data be kept after the publication of the first paper from the project?	**Forever**
Procedure for Informed Consent	
How will informed consent be recorded? (check all that applies) Reminder: please attach informed consent that will be used in the study	[✔] Written Consent [✔] Audio-recorded Consent [✔] Online/Email recorded Consent [ ] Others, please specify:

If you will not obtain a recorded informed consent, answer the questions that follow:

Why does the waiver of informed consent not pose a threat to the welfare and rights of the participants?

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2.03 Version No.: 1 Effectivity Date: July 2016

Why is recording an informed consent not practical for the proposed study?

	Yes	No	Not Applicable
1. Will the research involve students who will be receiving course credits for their participation? **If YES, please attach a copy of the consent form and a summary of the debriefing process that will help participants understand how their participation in the research has provided a relevant learning experience to the crediting course.**		✔	
2. Does the study involve participants below 18 years old or those who are unable to give their informed consent? **If YES, please attach a copy of the parental consent form.**	✔		
3. Is there a possibility that the research can induce physical and/or psychological harm to the participants? Will they experience pain or some discomfort as a result from their participation in the research? **If YES, please attach an acceptable argument that outlines the benefits of doing the research and how they outweigh the cost of harming the participants.**		✔	
4. Will the participants be deliberately falsely informed or made unaware that they are being observed? Will they be misled in a way that they will possibly object to or show unease when told of the real purpose of the study? **If YES, please attach an acceptable argument that outlines the benefits of doing the research and how they outweigh the cost of harming the participants.**		✔	

5. Will the research involve the discussion of, or questions on, sensitive topics (e.g. sexual activity, substance abuse, or mental health)? **If YES, please make sure that the informed consent form explicitly states that sensitive questions will be posed and that you will safeguard the anonymity of the participants and ensure confidentiality. Please attach a copy of your informed consent form and your instrument.**		✔	
	Yes	**No**	**Not Applicable**
6. Will the research involve the administration of drugs, or other substances to the participants? **If YES, please attach an acceptable argument that outlines the benefits of doing the research and how they outweigh the cost of harming the participants.** **Please also attach a description of the procedure that will ensure that the participants will be brought back to their physical and psychological states prior to their participation in the research.**		✔	
7. Will biological samples (e.g. blood, saliva, urine) be obtained from the participants? **If YES, will this involve invasive procedures? Please attach a description of these procedures.**		✔	
8. Will genetic materials be obtained from the biological samples? **If YES, please attach a description of the procedures that will ensure confidentiality. Please attach the informed consent form.**		✔	
9. Will financial inducements (other than reasonable expenses, like transportation or meal allowances) be offered to the participants for their participation in their research?		✔	

If YES, the researcher(s) should be mindful of how the inducements can influence the participants' responses or behaviors during the research. Indicate the financial inducements offered to the participants: ____			
10. Is there a possibility for groups or communities to be harmed by the dissemination of the research findings? **If YES, please attach a description of procedures to ensure the anonymity and confidentiality of the research findings.**		✔	
11. Will the results of this study have a commercial value? If yes, do you intend to apply for a patent for the output of this research? Please check: _____ Yes _____ No		✔	

FOR PROPONENTS WHO WILL GATHER NEW DATA ONLY, PLEASE STOP ANSWERING.

Use of Pre-existing Data collected from Human Participants		
Indicate the dataset from which the data for the study will be sourced		
Is the data publicly available, i.e., the access to which does not necessitate an approval process?		Yes Please indicate where the dataset is available:
		No Please indicate/attach the approval authority for access:
		Yes **Please attach the Consent Form used in the original study.**
		No

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2.03 Version No.: 1 Effectivity Date: July 2016

Was the original dataset originally collected for the present study's purpose?		**Please attach the Information Collection Statement (i.e., the statement given to informants providing them with the rationale for the collection of specific information).**
Does the original data set contain sensitive data, that is information that an individual would not likely want to be disclosed publicly, e.g., data on sexual activities, substance use?		Yes **Please describe the type of sensitive data to be used in the present research:**
		No
Does the original dataset have personal identifiers?		No *(This means that neither the researcher nor the participant provided any personal identifiers)*
		Yes, specifically: ______ Direct *(i.e., the participant provided personal details like name and address)* _____ Indirect (*i.e., the participant was given a respondent code to make the participant identifiable)*
Will new data be collected and analyzed along with data from the existing dataset?		Yes **Please answer questions on page 3-5.**
		No

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2(J) Version No.: 1 Version Date: March 2017

DE LA SALLE UNIVERSITY

Checklist F
Research Ethics Checklist for Investigators conducting Action Research

This checklist must be completed AFTER the De La Salle University Code of Research Ethics and Guide to Responsible Conduct of Research has been read and BEFORE gathering data. The University Code of Research Ethics is available at http://www.dlsu.edu.ph/offices/urco/forms/URCO-Code-of-Research-Ethics_August2011.pdf

NOTE: This checklist is completed after the research proponent fills out the General Checklist Form and Checklist A.

Only answer this Checklist if you will be conducting ACTION RESEARCH.

The following items refer to important ethical considerations in the conduct of action research. Provide a check for the appropriate answer to each question.

	Yes	No	Not Applicable
1. Will you have minors as participants in your study? Minors are individuals under the age of 18 years old. **If YES…Obtain parental/guardian consent and participant assent to participate in your study. Attach the parental consent and assent forms to your proposal. The consent forms should indicate the measures you will undertake to ensure confidentiality and protect the participants.**	✔		
2. Will you be conducting a growth plan for an existing organization? A growth plan is a strategy paper for existing businesses (e.g. family businesses or own businesses existing for at least 3 years and are owned or managed by MS in Entrepreneurship students) **If YES…Obtain informed consent from the owners and board of directors of the host firms. In addition, provide a waiver indicating that the recommended strategies for implementation do not necessarily reflect the University's stand and are only attributed to the proponent's opinions at the time of the conduct**		✔	

of research and the period covered for the implementation of these strategies.			
3. Will your research involve the participation of vulnerable stakeholders? Vulnerable stakeholders are persons whose situation or characteristics may make them unable to provide free and informed consent to participate in the research. This group includes children, institutionalized, persons, students, those who have cognitive impairments, customers, employees in subordinate positions, suppliers, students, etc. **If YES…Indicate in your proposal how appropriate and just compensation (proportionate to the contribution in the research, research budget, and local conditions) will be provided to these vulnerable and marginalized participants. Describe the informed consent process to be undertaken with these participants. This includes, but is not limited to, written informed consent, verbal informed consent, plain language statements, and translated consent forms.**	✔		
4. Is the research involving what the participant would ordinarily be required to do in his/her given setting, e.g., the classroom, the workplace? **If YES… Emphasize to the student participant that his/her freedom not to participate in the research will not earn any sanction. An alternative activity should be offered to the participant in lieu of the research so as not to disadvantage the students who opt not to participate in the classroom-based research. The student participants need to be informed of their freedom to "opt out" at any time they wish.** **For participants in corporate settings where actual participation is part of his/her mandatory work activities, they need to be informed of their freedom to "opt out" of being cited as a respondent/informant of the action research.** **Participants will also be informed of their right to corroborate data and the researcher's interpretation. Participants should be informed that they may ask data analysis to be revisited if there was any misinterpretation in the process of analysis or when the report can potentially place them in a negative light.**	✔		

5. Will the research be requiring the participants to be involved in an activity not part of their regular, daily setting, e.g. the classroom, the workplace? **If YES… Emphasize to the student participant that his/her freedom not to participate in the research will not earn any sanction. An alternative activity should be offered to the student participant in lieu of research participation.** **The student participants need to be informed of their freedom to "opt out" at any time they wish.** **For participants in corporate settings where actual participation is part of his/her mandatory work activities, they need to be informed of their freedom to "opt out" of being cited as a respondent/informant of the action research.**		✔	
6. Does the research involve the collection of data beyond the normal activities engaged by participants? **If YES…obtain prior consent from participant and/or the parent/guardian for these research activities.**		✔	
7. Does your procedure involve possible data gathering that will take place outside of the action research setting/environment? **If YES… Explicitly state in your procedure the manner in which data will be collected outside of the action research setting.**		✔	
8. Will your research engage your participants in roles as active informants, co-researchers or researchers? **If YES… Specify in your research proposal the level of participation, especially as regards to the focus of decision making, the content, nature, frequency, duration, benefits and potential impact of your co-researchers' or informants' participation.**		✔	
9. Is your role and status in the institution (e.g. teacher in the classroom, administrator of the school, business owner, or manager		✔	

of the corporate firm) going to affect the conduct of the research? **If YES… Indicate how you will address potential biases.**			
10. Is the agreement regarding ownership of data among involved parties in the research ambiguous? **If YES…include in the methodology section of your research proposal and the informed consent form a clear statement of the purposes, procedures, risks, and benefits of the research project, as well as the obligations and commitments of both the participants and the researchers.** **If NO…stipulate in the methodology section and informed consent form how data will be shared.**		✔	
11. Is there a probability that a participant will not consent to the conduct of your action research? **If YES… Present the alternative activities/intervention in the proposal. Provide a straightforward and transparent agreement between the researcher and the research participants regarding the terms of engagement in the research process.**		✔	
12. Is there a probability that a participant will drop out from the study? **If YES… Present a course of action in the methodology section of your research proposal.**		✔	
13. Is there a possibility that your action plan/intervention will inflict unintended harm to your participants? **If YES… what measures do you have to detect and address these unanticipated adverse consequences? Discuss how you intend to address this concern in your research proposal.**		✔	
14. Is a commercial product an end goal of your research? If yes, do you want to apply for a patent for this product? Please check: _____ Yes		✔	

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2(J) Version No.: 1 Version Date: March 2017

_____ No			

De La Salle University

De La Salle University
College of Computer Studies

You are being asked for the participation of your child in a research entitled,

FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children

This study is conducted by Paolo Miguel Ato, Mart Henrick Gamutan, Antoine Mikhael Salcedo, Josh Cezar Valencia, all B.S. Computer Science students, as a part of their requirements for completing their undergraduate thesis. The experiment is under the supervision of Mr. Jordan Aiko Deja and Dr Rafael Cabredo from the College of Computer Studies.

A. INTRODUCTION

The goal of the research is to identify and model the human factors and behaviors that children exhibit when tasked with learning how to compose music using a mobile musical tool. Children aged 5-8 will be observed in order to gather data. In testing, the children will then be asked to use the application by doing tasks as indicated by the researchers.

There may be some terms or words that are too technical and might not be understandable to you. In this case, you may ask questions to the researchers about these unknown terms so that they can pause and explain. If in any case you have questions after the observation and/or testing, you may ask any of the researchers directly.

B. POTENTIAL RISKS AND DISCOMFORT

There are no reasonably foreseeable risks, discomforts, or disadvantages connected to you and your child's participation.

C. POTENTIAL BENEFIT TO SUBJECTS AND/OR SOCIETY

Your child's participation in this study will provide insights to the researchers with respect to designing a mobile application tool that will help children learn music in a playful manner. This will help developers design better products that can be used to teach children.

D. CONFIDENTIALITY

The researchers will not share your personal information to anyone outside of the research team. Your real name will be removed in all publications and outputs. Any information about you will be marked by a number instead of your name (we will refer to you as P1, P2, etc).

Only members of the research group will have access to personally identifiable data and all the information will be securely stored and destroyed when it is no longer needed.

Information obtained through this study and that can be used to identify you will **remain confidential** and will only be disclosed with your prior permission, or as required by law. You may ask the researchers questions now or later. You are also encouraged to seek advice from someone else before confirming to this research.

E. PROCESSING AND STORING YOUR DATA

Your responses will be transcribed and exported to the researchers online database to be stored for data analysis. The data will be stored in a safe place and only we will have access to it. If a person's identity can be disclosed from the questionnaire or any other digital file it will be destroyed OR permanently deleted by the end of the project, while the response data will be kept only in the anonymized form.

In case of a data breach, the researchers will undertake all steps necessary to minimize any negative consequences. You will receive a notification about the details of the Data Breach, the information lost and the actions taken as soon as possible.

F. PARTICIPATION AND WITHDRAWAL

Your participation in this study is completely voluntary. You may withdraw at any time during the data gathering process without any consequence or penalty. Should you decide to withdraw, the data which you were able to contribute will be disposed of properly.

G. YOUR RIGHTS

You have the right to access your personal data, to correct it, to erase it, to restrict its processing, the right to data portability, and the right to object to in accordance with Sec.16 of the Data Privacy Act of 2012. You can also withdraw your consent to process your personal data at any time according to Sec.16 of the Data Privacy act of 2012 without any consequences.

H. USAGE OF YOUR DATA

Processed data will be used in research publications, for education purposes and for future research. As a participant you can receive a summary of the results upon request.

I. IDENTIFICATION OF RESEARCHERS

Should you have other concerns or questions regarding the research, please feel free to contact any of the following researchers:

Paolo Miguel Ato
Ladderized Undergraduate Student
College of Computer Studies

De La Salle University Manila
Contact No.: 0995 488 7524
Email: paolo_ato@dlsu.edu.ph

Mart Henrick Gamutan
Ladderized Undergraduate Student
College of Computer Studies
De La Salle University Manila
Contact No.: 0920 970 7074
Email: mart_gamutan@dlsu.edu.ph

Antoine Mikhael Salcedo
Undergraduate Student
College of Computer Studies
De La Salle University Manila
Contact No.: 0927 234 6808
Email: antoine_salcedo@dlsu.edu.ph

Josh Cezar Valencia
Undergraduate Student
College of Computer Studies
De La Salle University Manila
Contact No. 0906 472 6584
Email: josh_cezar_valencia@dlsu.edu.ph

De La Salle University

CONSENT to PARTICIPATE in the Data Gathering for

FireFlyX: Designing Interactions for a Mobile Musical Learning Tool for Children

I hereby confirm that (please tick the appropriate boxes):

TAKING PART IN THE PROJECT		
1.	I have read and understood the information about the research as provided in the above Information Sheet.	☐
2.	Me and my child have been given the opportunity to ask questions about my participation in the data gathering done by the researchers.	☐
3.	As a parent, I allow my child to participate in the data gathering and am aware that my answers will be analyzed by the researchers for the context of the study conducted.	☐
4.	As a parent, I am aware that my child's participation in the data gathering is voluntary; I am given the option to withdraw my child from participating in the study at any time.	☐
USING THE INFORMATION I HAVE PROVIDED FOR THE STUDY		
5.	The procedures for confidentiality have been clearly explained to me.	☐
6.	I agree for the data that my child and I will provide to only be archived by the researchers for research purposes in the context of this study.	☐
7.	Please select **only one** of the following:	
	a. I am **allowing** other researchers to have access to the data collected from this study if they fully agree to preserve the confidentiality of the data gathered and to the terms specified on this form.	☐
	b. I am **not allowing** other researchers to have access to the data collected and consent only of its use on this study.	☐

PARTICIPANT:

Name of Child ______________________ Signature over printed name of Parent\Guardian ______________________

Date:

RESEARCHERS:

Name and Signature of Researcher ______________________ Name and Signature of Researcher ______________________

De La Salle University

__________________________ __________________________

Name and Signature of Researcher Name and Signature of Researcher

REQUEST FOR PARTICIPANT INFORMATION

Strictly for the purposes of this study, the researchers would like to request for some of your personal information. This will only be used in order to contact you for further clarifications (if applicable) regarding your input and feedback done on this study. Your information will **remain confidential**, and will only be disclosed with your permission, or as required by law.

PARTICIPANT INFORMATION SHEET

Name of child:

____

Participation date:

____

Age of participant:

_______ years old

Sex of participant (please encircle only one among the choices):

M / F

Contact number of parent/guardian:

____

De La Salle University
College of Computer Studies

You are being asked for your participation in a research entitled,

FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children

You must be 18 years old or above in order to participate in this study. Your participation is completely voluntary. Carefully read the information below and you are encouraged to ask any questions regarding the experiment that you do not understand.

This study is conducted by Paolo Miguel Ato, Mart Henrick Gamutan, Antoine Mikhael Salcedo, Josh Cezar Valencia, all B.S. Computer Science students, as a part of their requirements for completing their undergraduate thesis. The experiment is under the supervision of Mr. Jordan Aiko Deja from the College of Computer Studies.

A. INTRODUCTION

The research goal is to identify and model the human factors and behaviours that children exhibit when given the task of learning how to compose music with a mobile musical tool. Children aged 5-8 will be observed in order to gather data, we will also be interviewing music teachers to get insights on how children in these ages learn music and to ask how they teach their students. The children will be observed on how they learn music in class. Their actions will be noted and be used as data. In testing, the children will be asked to use the application while being recorded via camera. This will be done through 3 iterations while further improving the application by using the data through each step.

There may be some terms or words that are too technical and might not be understandable to you. In this case, you may ask questions to the researchers about these unknown terms so that they can pause and explain. If in any case you have questions after the observation and/or testing, you may ask any of the researchers directly.

B. POTENTIAL RISKS AND DISCOMFORT

There are no applicable risks

C. POTENTIAL BENEFIT TO SUBJECTS AND/OR SOCIETY

Your participation in this study will help clarify the insights we have acquired through observing children. The results of this research would greatly benefit children through a usable tool that children can use playfully.

D. CONFIDENTIALITY

The researchers will not share to other people that you are participating in this research. Your information will not be shared with anyone who is not part of the research.

Information obtained through this study and that can be used to identify you will **remain confidential** and will only be disclosed with your permission, or as required by law.

You may ask the researchers questions now or later. You are also encouraged to seek advice from someone else before confirming to this research.

E. PARTICIPATION AND WITHDRAWAL

Your participation in this study is completely voluntary. You may withdraw at any time during the data gathering process without any consequence or penalty. Should you decide to withdraw, the data which you were able to contribute will be disposed of properly.

F. IDENTIFICATION OF RESEARCHERS

Should you have other concerns or questions regarding the research, please feel free to contact any of the following researchers:

Paolo Miguel Ato
Undergraduate Student
College of Computer Studies
De La Salle University Manila
Contact No.: 0995 488 7524
Email: paolo_ato@dlsu.edu.ph

Mart Henrick Gamutan
Undergraduate Student
College of Computer Studies
De La Salle University Manila
Contact No.: 0920 970 7074
Email: mart_gamutan@dlsu.edu.ph

Antoine Mikhael Salcedo
Undergraduate Student
College of Computer Studies
De La Salle University Manila
Contact No.: 0927 234 6808
Email: antoine_salcedo@dlsu.edu.ph

Josh Cezar Valencia

De La Salle University

Ladderized Undergraduate Student
College of Computer Studies
De La Salle University Manila
Contact No. 0906 472 6584
Email: josh_cezar_valencia@dlsu.edu.ph

CONSENT to PARTICIPATE in the Data Gathering for
"FireFlyX: Designing Interactions for a Mobile Musical Learning Tool for Children"

I hereby confirm that (please tick the appropriate boxes):

TAKING PART IN THE PROJECT		
1.	I have read and understood the information about the research as provided in the above Information Sheet.	☐
2.	I have been given the opportunity to ask questions about the study and my participation.	☐
3.	I am giving permission for my participation in the study.	☐
4.	I understand that this is voluntary; I can withdraw from the study at any time and I do not have to give any reason for why I no longer want to take part.	☐
USING THE INFORMATION I HAVE PROVIDED FOR THE STUDY		
5.	The procedures for confidentiality have been clearly explained to me.	☐
6.	I agree for the data that I will provide to only be archived by the researchers for research purposes in the context of this study.	☐
7.	Please select **only one** of the following:	
	a. I am **allowing** other researchers to have access to the data collected from this study if they fully agree to preserve the confidentiality of the data gathered and to the terms specified on this form.	☐
	b. I am **not allowing** other researchers to have access to the data collected and consent only of its use on this study.	☐

PARTICIPANT:

____
Signature over printed name of Teacher

De La Salle University

Date:

RESEARCHERS:

__________________________ __________________________

Name and Signature of Researcher Name and Signature of Researcher

__________________________ __________________________

Name and Signature of Researcher Name and Signature of Researcher

REQUEST FOR PARTICIPANT INFORMATION

Strictly for the purposes of this study, the researchers would like to request for some of your personal information. This will only be used in order to contact you for further clarifications (if applicable) regarding your input and feedback done on this study. Your information will **remain confidential**, and will only be disclosed with your permission, or as required by law.

PARTICIPANT INFORMATION SHEET

Name of participant:

____

Participation date:

____

Age of participant:

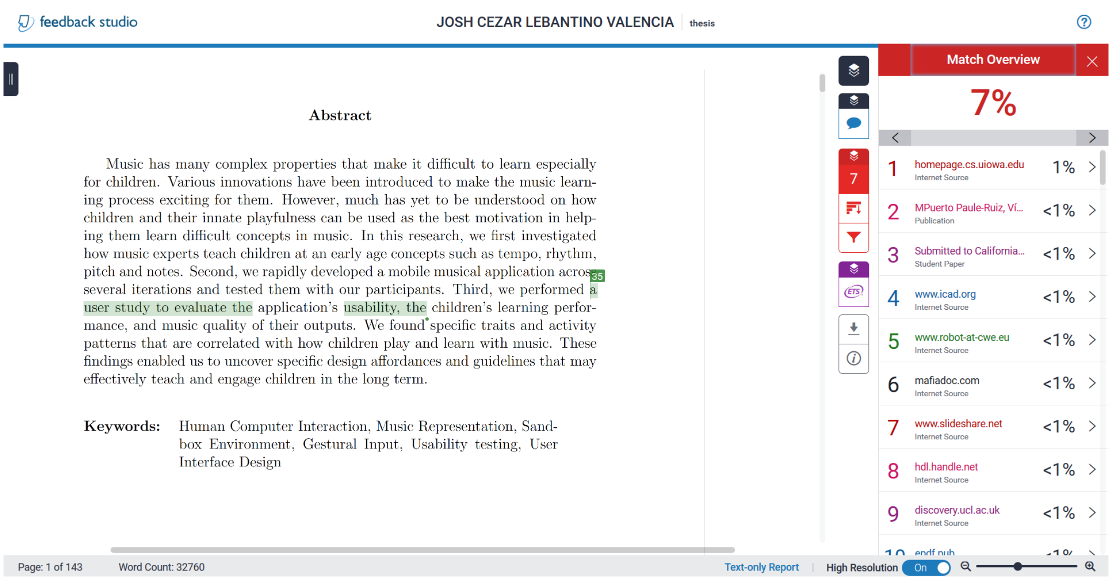
_______ years old

Sex of participant (please encircle only one among the choices):

M / F

Appendix B

Turnitin Similarity Report



Appendix C

Record of Contribution

Departmental Record of Contribution

This form should be submitted along with the THSST-3 final deliverables. The contribution disclosed herein will formalize the contribution of each of the proponents and the adviser to the research. It is important that the proponents and the adviser agree with the figures and remarks imparted here, and it is expected that all has arrived to the same conclusion in good faith.

Title	Proponents	
FireflyX: Designing Interactions for a Mobile Musical Learning Tool for Children	*Proponent 1 (P1)*	**Ato, Paolo Miguel, B.**
	Proponent 2 (P2)	**Gamutan, Mart Henrick, A.**
	Proponent 3 (P3)	**Salcedo, Antoine Mikhael, M.**
	Proponent 4 (P4)	**Valencia, Josh Cezar, L.**
	Adviser (A)	
	Jordan Aiko P. Deja	

Key Event	*Contribution in %* *(N/A allowed except for total)*					Remarks
	P1	*P2*	*P3*	*P4*	*A*	
Idea conceptualization	15	5	15	15	50	
Research formalization	20	20	20	20	20	
Tool development	15	55	15	15	N/A	
User Testing	30	5	30	30	5	
Document Writing	25	15	25	25	10	
Overall contribution*	105	100	105	105	85	

Paolo Miguel B. Ato
Proponent

Mart Henrick A. Gamutan
Proponent

Antoine Mikhael M. Salcedo
Proponent

Josh Cezar L. Valencia
Proponent

Jordan Aiko P. Deja
Adviser

* this row must be filled

Appendix D

Use Cases

For the headers of each row the cases that will be used are:

- Trigger - The goal that the user case is designed for
- Primary Actor - Main entities that are directly involved in achieving goal
- Supporting Actors - Additional entities that can influence achieving the goal but are not directly involved
- Preconditions - Conditions that need to be satisfied before the process starts
- Process Steps - Step by step actions the primary actor does in order to achieve the goal
- Minimal Guarantees - The outcome in the scenario that the goal is only partially
- Success Guarantees - The outcome in the scenario that the goal is fully done

Use Case 1: Child explores the workspace in the screen	
Trigger	Upon entry on the workspace the child is curious on the assets found on the screen
Primary Actor	Child
Supporting Actors	Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu The child has been oriented in using the application
Process Steps	1. The child taps on the many assets found on the screen 2. The child selects the first firefly in the jar, thus activating firefly creation

Use Case 2: Select tempo for the fireflies in an environment to represent	
Trigger	The child wants the firefly to have a speed of a certain tempo
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu should be the first part that is modified in a specific firefly
Process Steps	1. The child taps the firefly's body 2. The child taps the color of the tempo arranged from slowest to fastest in the pop up settings 3.When the tail is selected later on it should show the same color selected by the child

Use Case 3: Select pitch for the each note to represent	
Trigger	The child wants the firefly to represent a certain pitch for each note
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu The firefly should have its parts like the wings, body, and tail already configured
Process Steps	1. The child taps on the firefly 2. The child configures the wings, body, and tail 3. The child selects Feed Me to start editing the candies 4. The child puts the candies in the locations of the pitch notes in the staff

Use Case 4: Select number of repetitions of the rhythm	
Trigger	The child would want the a pattern to have a number of repetitions
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu firefly can already have other parts already modified
Process Steps	1. The child taps the firefly's wing 2. The child selects a wing size from the six possible in the pop-up settings, where the smallest with a wing pattern of one would mean it will repeat only in one measure and the biggest with a wing pattern of six where it will repeat for six measures.

Use Case 5: Select speed of the rhythm	
Trigger	The child wants to the specific speed in a note
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu firefly can already have other parts already modified
Process Steps	1. The child taps the firefly's wing 2. The child selects the initial speed of the rhythm from buttons representing the different music notations (whole,half,quarter,eight notes/rests)

Use Case 6: Select the beat-rest pattern of the firefly	
Trigger	The child would select the beat-rest pattern that the firefly will play
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu firefly can already have other parts already modified
Process Steps	1. The child taps the firefly's tail 2. The child selects a pattern that represents beat-rest patterns in the pop-up settings 3. The child can see the candies below which indicates the pattern of that tail

Use Case 7: Change tempo for the fireflies in the environment to represent	
Trigger	The child wants to change the tempo of the fireflies in the environment
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu should be the first part that is modified in a specific firefly The tempo was already set earlier
Process Steps	1. The child taps the firefly's body 2. Child taps on another color in the pop-up settings 3. If more than 1 firefly has been made it will change the color of all the fireflies inside the jar 4.When the tail is selected later on it should show the modified color by the child

Use Case 8: Change pitch for the firefly to fly on	
Trigger	The child wants to change the pitches in the current configuration of the firefly
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu The firefly should have its parts like the wings, body and tail already configured The candiess representing the pitches was already set earlier
Process Steps	1. The child taps the firefly 2. The child selects Feed Me to start editing the candies 3. The child drags the candies representing the current pitch to a new location of choice

Use Case 9: Change number of repetitions of the rhythm	
Trigger	The child would want the specific rhythm to change in consecutive measures
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu The firefly can already have other parts already modified The number of repetitions was already set earlier
Process Steps	1. The child taps the firefly's right wing 2. Child taps on another wing size in the pop-up settings

Use Case 10: Change the speed of the rhythm	
Trigger	The child wants to change the speed of the wing
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu firefly can already have other parts already modified The speed of the wings was already set earlier
Process Steps	1. The child taps the firefly's left wing 2. Child taps on another initial note speed in the pop-up settings

Use Case 11: Change the beat-rest pattern of the firefly	
Trigger	The child wants change the beat-rest pattern that the firefly will play
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu The firefly can already have other parts already modified The beat-rest pattern was already set earlier
Process Steps	1. The child taps the firefly's tail 2. Child taps on another tail pattern from the 5 in the pop-up settings 3. The child can see the candies below which indicates the pattern of that tail that they changed

Use Case 14: Start jar playback	
Trigger	The child wants to hear what sounds the fireflies they made would produce
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu At least 1 firefly must have been edited completely
Process Steps	1. The child taps on the cork of the jar containing the fireflies 2. The child presses confirm to play in the play jar prompt

Use Case 15: Return to rhythm screen	
Trigger	The child wants to change the pattern they has selected once already is in the pitch screen
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu They are at the screen where they are editing the pitch
Process Steps	1. In the pitch screen the child taps on the Last Screen button 2. He will then be taken back to the screen where they configured the firefly parts

Use Case 16: Reset all pitches of the candies	
Trigger	The child wants to reset all pitches that was configured in placing the candies to produce pitch
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu They are at the screen where they are editing the pitch They have placed candies in a certain pitch already
Process Steps	1. In the pitch screen the child taps on the Clear button 2. The candies will reset back to the bottom ready to be configured again

Use Case 17: Go to next firefly	
Trigger	The child is finished with the current firefly and wants to move to configure the next
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu They are at the screen where they are editing the pitch They have placed candies in their desired pitch already The user is not yet on the last (5th) firefly if they are this button will not appear
Process Steps	1. In the pitch screen the child taps on the Next Firefly button 2. They will be redirected back to the screen to edit the new firefly 3. They will also notice that they previous firefly they created is now inside the jar

Use Case 18: Save Jar	
Trigger	The child wants to save his current progress so they can look back into it when it is not being used anymore
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has already pressed a task in the main menu There is a jar in the playback history
Process Steps	1. The child navigates to the pitch screen presses the save button

Use Case 19: Load Jar	
Trigger	The child wants to load a previous jar they made in order to listen to the playback history in it
Primary Actor	Child
Supporting Actors	Firefly object Sandbox FireflyX
Precondition	The user has pressed start in the main menu There is a jar that was alreay made in a specific task
Process Steps	1. The child navigates to the settings above and presses the load button 2. The child chooses one of the saved albums to load 3. Upon confirmation, the current jar is saved automatically and then proceeds to load the selected jar

Appendix E

User Personas

E.1 Shy Shirley

E.1.1 Bio

- 7 years old
- Stays home to play alone
- Likes to reads books

E.1.2 Goals

- To gain confidence
- Learn music with minimum interaction

E.1.3 Frustrations

- Interacting with other people
- Stays in comfort zone
- Needs to be comfortable in order to learn

E.2 Talkative Teddy

E.2.1 Bio

- 6 years old
- Likes to play with friends outside

E.2.2 Goals

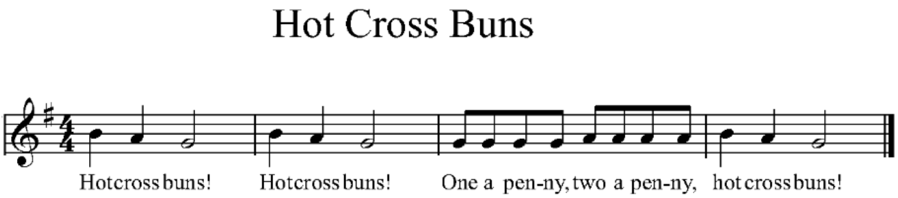
- To be friends with everyone
- To get home as early as possible from his music lessons
- To be rewarded for things he does

E.2.3 Frustrations

- Gets easily distracted

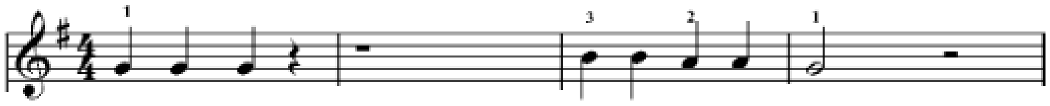
Appendix F

Sample Music Sheet



://www.overleaf.com/project/5c8b6cf3993d3602b379bda4

Old MacDonald



Appendix G

Initial Prototype Screen Flows

G.1 Screen Flows

G.1.1 Splash Screen

Figure G.1: Splash Screen

The Splash Screen is the first screen shown to the child when the application is opened. The splash screen will last for 3 seconds.

G.1.2 Main Menu

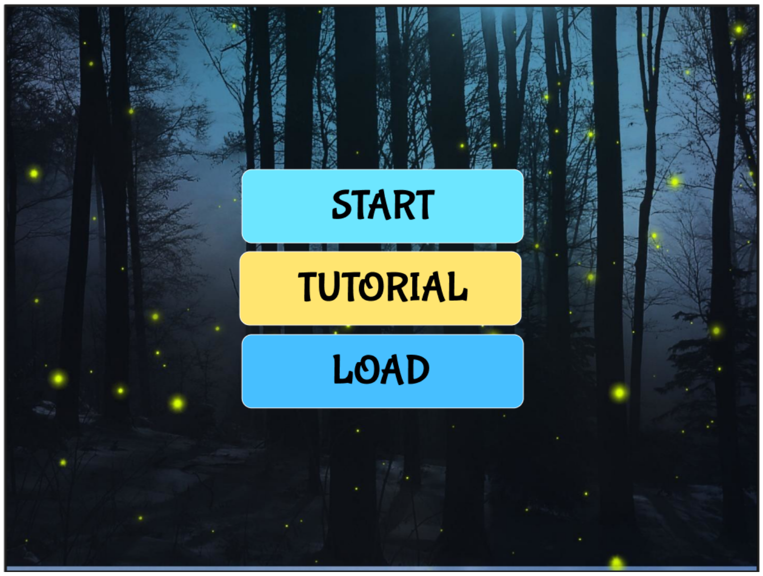


Figure G.2: Main Menu

The Main Menu (figure G.2) is the next screen that will show after the splash screen, here the child may tap between 3 buttons, namely: start, tutorial, and load. The start button will open a blank workspace. The tutorial button will show the user how to assemble the firefly step by step and the different gestures that will be utilized. The load button will open the Load Menu where the user may load saved workspaces.

G.1.3 Start New

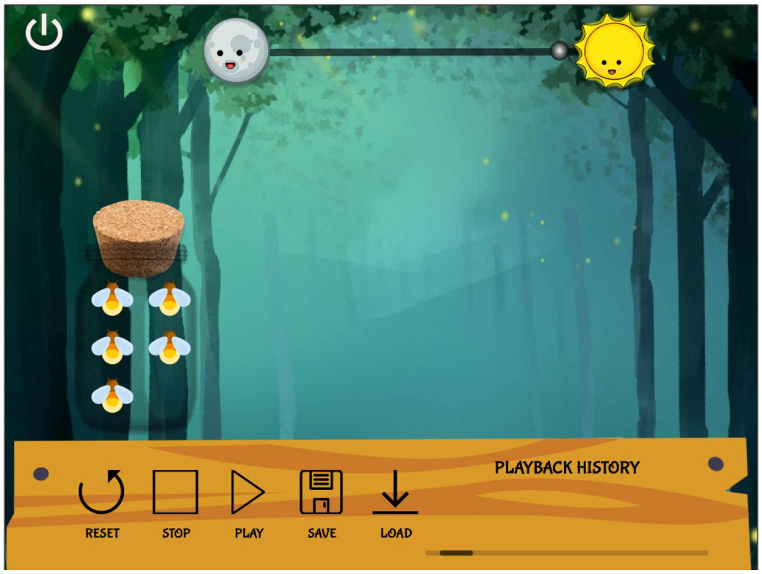


Figure G.3: Blank Workspace

After tapping Start button this is the blank workspace that the child will see figure G.3. In this screen, the user will see a jar of fireflies, and other playback controls. This screen is important as this follows the principle of an Obvious Starting point as it becomes a starting point in the application that the child can first explore different interactions and also a safe space for the child as they know that if they commit something wrong they can always go back to this screen.

G.1.4 Edit Firefly

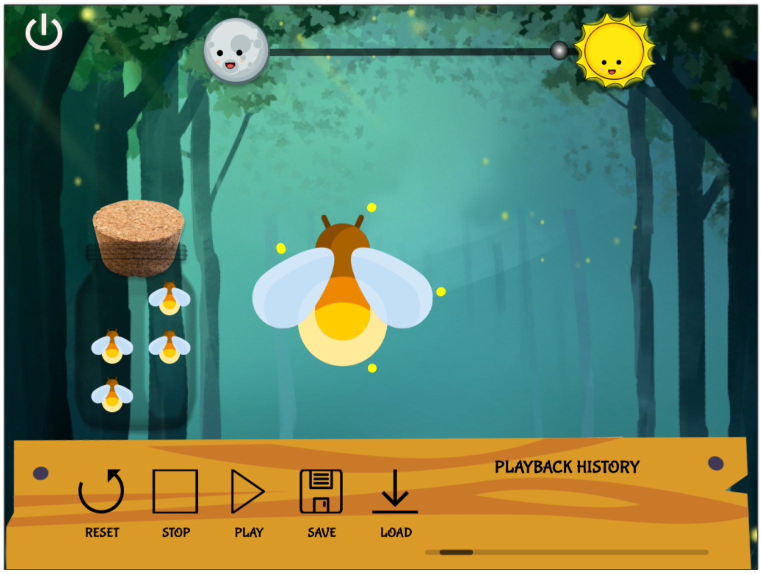


Figure G.4: Editing a Firefly

After Loading a blank workspace, the child may choose a firefly model to edit by tapping any of the small fireflies in the jar. After tapping a firefly model in the jar, the firefly model will be enlarged so that the child may tap a firefly part to edit. We decided to use simple tap gestures for tasks involved in manipulating the firefly parts to make it easier for the child to remember them and to reduce the load of the actions that can be caused by using other gestures.

G.1.5 Edit Firefly Body

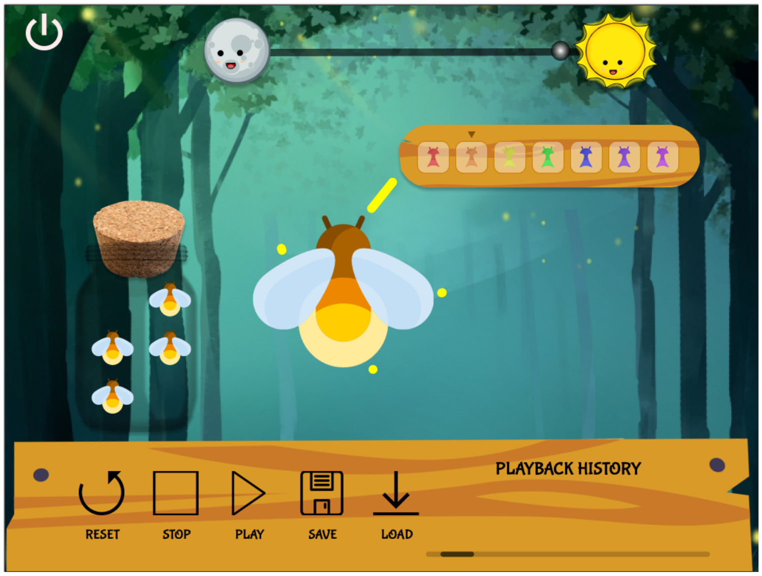


Figure G.5: Editing Firefly Body

After choosing a firefly model to edit, the child may tap the body to show the popup settings that can configure the properties. The different body color corresponds to different tempos.

G.1.6 Edit Firefly Wing

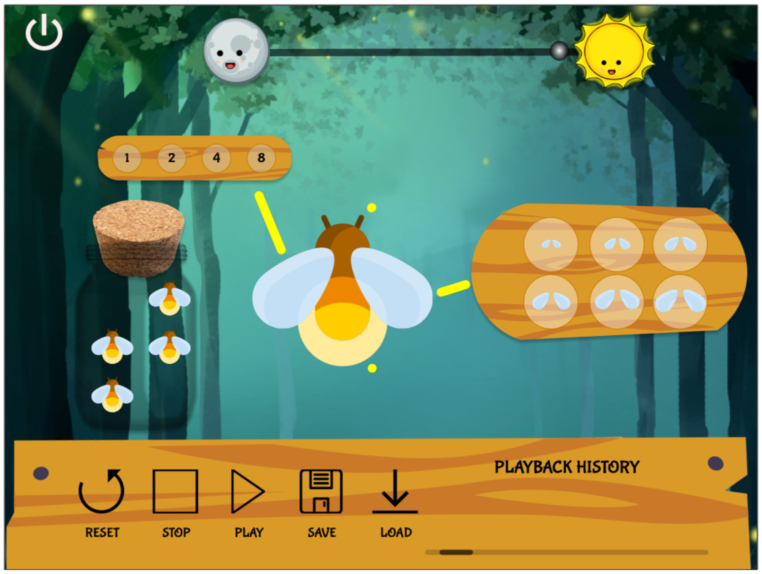


Figure G.6: Editing Firefly Wing

After choosing a firefly model to edit, the child may tap the wing to show the popup settings that can configure the properties. For the wing popup settings, there will be two bubbles. The first bubble is for configuring the wing speed. The different wing speed corresponds to length of notes. The other wing configures the wing size. The different wing size corresponds to different number of repetitions.

G.1.7 Edit Firefly Tail Light

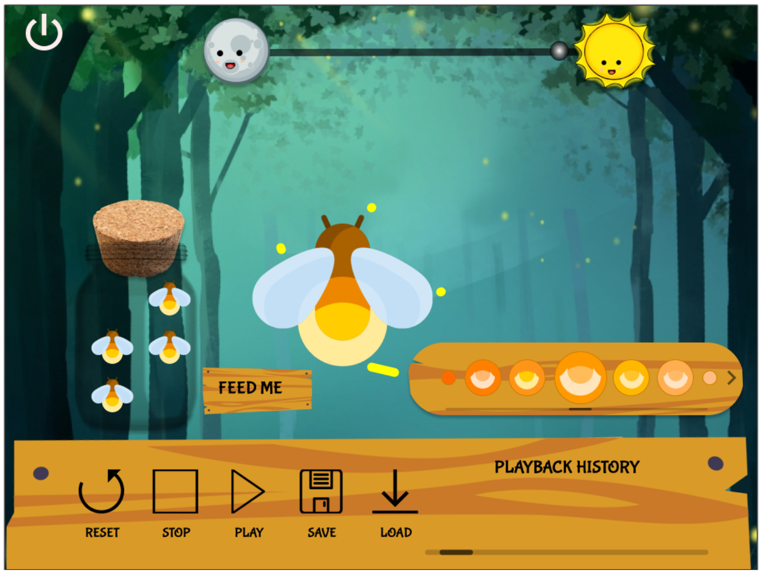


Figure G.7: Editing Firefly Tail Light

After choosing a firefly model to edit, the child may tap the tail light to show the popup settings that can configure the properties.

G.1.8 Feed Firefly

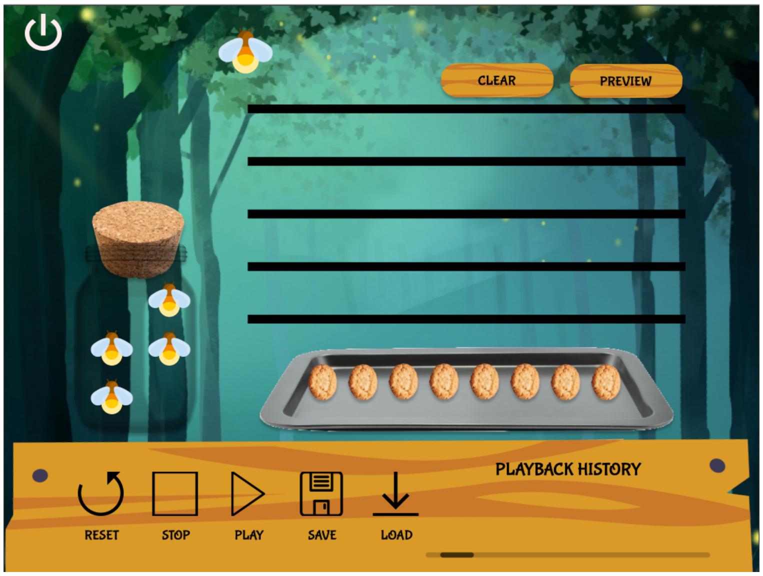


Figure G.8: Set Pitch of Notes by Feeding the Firefly

After choosing the preferred tail light, the user may tap the feed me button in order to set the biscuits for the path of the firefly model which will also determine the pitch of the notes that the firefly model will play.

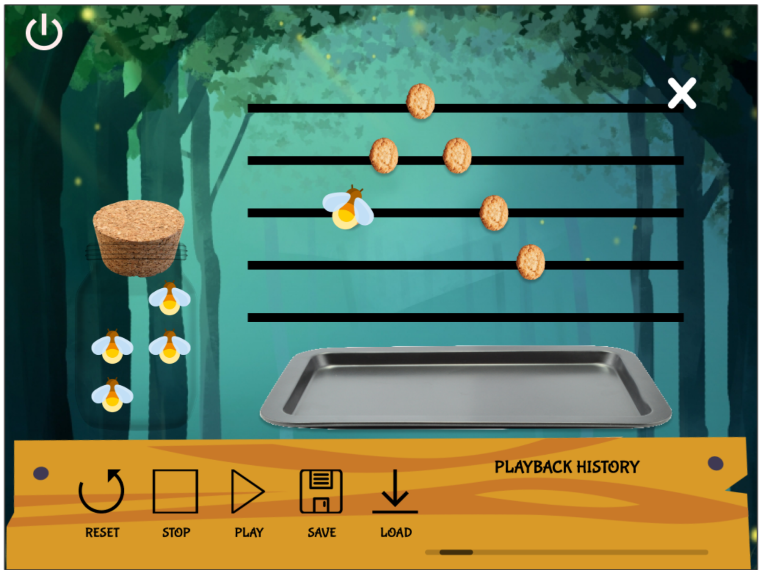


Figure G.9: Preview Flight Pattern

The user may also see a preview of how the firefly model will fly based on their placed biscuits by tapping the preview button.

G.1.9 Change Currently editing firefly

Figure G.10: Choosing Different Firefly to Edit

In order to change the currently editing firefly model to a different firefly model. The child can simply click any of the smaller fireflies to enlarge and the previously enlarged firefly model will minimize. We wanted this action to show a contrast of sizes so that the child focus will shift from the one currently made to the new one.

G.1.10 Release Fireflies to start playback

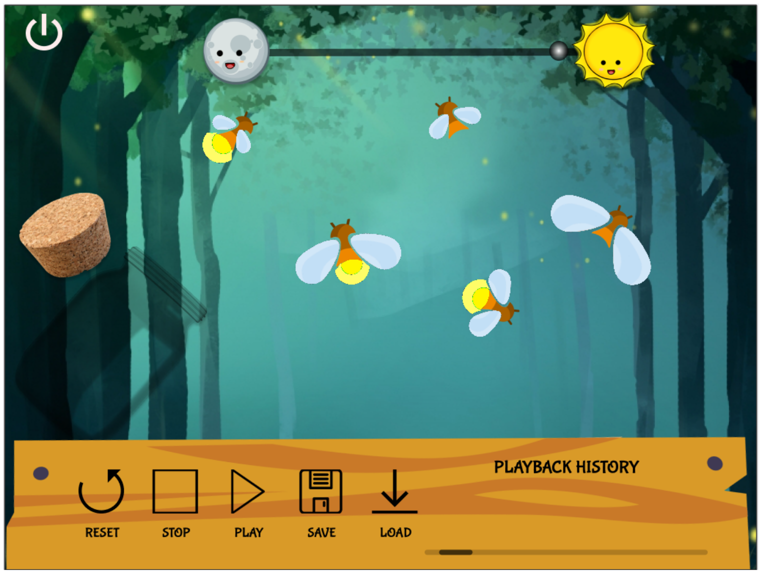


Figure G.11: Releasing the Fireflies

After editing the firefly models to desired configurations, the child can tap on the lid of the jar to release all the fireflies and start the rhythm playback. This particular action was chosen as the start of the playback since we wanted it to represent the real world where fireflies are released and the child can see it as a way of familiarity.

G.1.11 Pause, Play, and Stop playback

Figure G.12: Play Pause, and Stop Controls

During playback, the child can pause and play the playback by toggling the play button. The stop button stops the current playback and starts the playback from the start on pause. The design of the buttons was made to be familiar buttons as they can already give the child an idea of what the buttons do.

G.1.12 Adjusting Volume

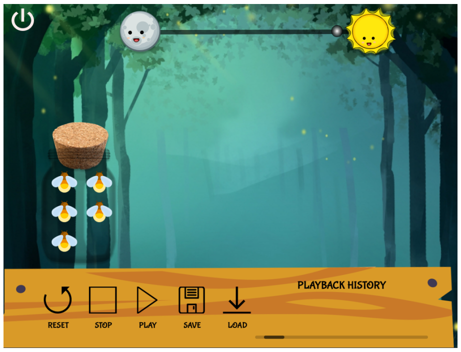


Figure G.13: Changing Volume of Playback

During playback, the child can adjust the volume of the playback by using the slider between the sun and moon. The moon will represent a lower volume and the sun will represent a higher volume. One finger drag gesture will be used as the child has more control of the desired volume they need with the use of this gesture.

G.1.13 Replay Previous Tracks

Figure G.14: List of Previous Tracks

After the firefly models are done with their playback, they are placed on to the playback history. The user may play these previous tracks again by dragging them to the jar on the left side then press play. This also was designed to represent the real world action of catching and releasing a firefly.

G.1.14 Reset Album

Figure G.15: Reset Album Button

If the child wishes to start fresh with a new blank album, the child may press the reset button to return everything to default. We needed to put this as the child can go back to the start which is a screen where he is already familiar with and he would know there is a way to undo their mistakes.

G.1.15 Save Album

Figure G.16: Save Album Button

The child may choose to save the existing album at anytime. Upon tapping the save button, the child is asked to input an author name and a title for the album. After confirming the album is then saved to the local device and can be loaded at anytime.

G.1.16 Load Album

Figure G.17: Load Album Button

The child may choose to load an existing album at anytime by tapping the load button.

G.1.17 Load Menu

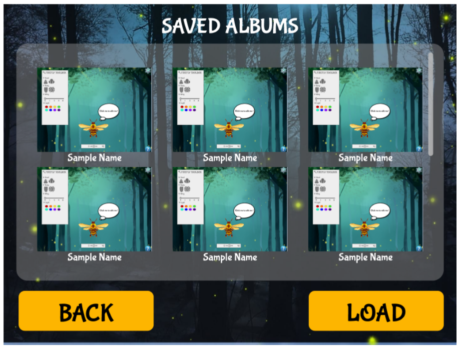


Figure G.18: Load Menu

The Load Menu shows all saved albums/workspaces. The child may tap on an album then press the load button to continue working on that album.

G.1.18 Exit to Main Menu

Figure G.19: Exit Button

The child may choose to tap the exit to main button at any time. When the button is pressed, a confirmation appears and when the child confirms that they want to exit to main menu, the screen will be transferred to the main menu. Same as the start screen this will give the child a sense of relief knowing they can go back to the start and begin all over again.

Appendix H

Preliminary Results

H.1 Demographic of Respondents

Interviewees were gathered by going to music schools and asking if the music teachers were fine being interviewed. We were able to interview 5 music teachers from different music schools. As a prerequisite, they are required to have at least 5 years of experience in teaching music by the time they participate. The demographic of the characteristics of these music teachers are shown in Table H.1.

H.2 Understanding Children Needs

From the interviews of the music teachers, we were able to compile a few key points that will help us identify the needs of children.

- It is important to have the children's attention before teaching anything to

Table H.1: Demographic Characteristics of Music Teachers

Characteristic	Total(n=5)
Age (mean $\pm SD[range]$)	39.8 $\pm 14.5[22-57]$
Sex (n [%])	
Male	4 [80]
Female	1 [20]
Years of Experience (mean $\pm SD[range]$)	20.6 $\pm 10.4[7-35]$
Preferred Teaching Method (n [%])	
Suzuki	3 [60]
Traditional	2 [40]
Specialty (n [%])	
Violin	2 [40]
Piano	1 [20]
Voice	1 [20]
Trumpet	1 [20]
Recommended Musical Fundamental to Teach (n [%])	
Rhythm	3 [60]
Pitch & Rhythm	2 [40]

them.

- The child should also be comfortable with the teacher, in addition to this the child must also feel safe and have trust in the teacher. This will help the child in expressing themselves.
- There are multiple ways to get the trust of children. Some are: icebreaker, pep talk, talking to them, and asking how their day is going.
- The teacher should assess them to know how to teach them.
- The teacher should adjust to the child.
- Repetition with development is important. Present the same idea differently.
- Teacher's passion will pass on the children.
- Rhythm must be taught first to children. It is usually done through clapping.
- Every session must be interesting and the curiosity of the child must be exploited.
- Learning should be step-by-step. Every part must be understood completely before moving on.
- Suzuki method teaches discipline to children. By having discipline, the child is able to study more efficiently alone.
- Traditional Method is just teaching the topic to the child. It is more of a by-the-book method, and usually instructional.

From the key points that were identified, a scenario map was created as shown in figure H.2

Figure H.1: The digital version of the scenario map taking into account the key points from the interviews. Blue = Step, Yellow = Question, Green = Idea, Pink = Solution.

Appendix I

Initial Testing Results

I.1 Iteration 1 Testing Results

	Age	Years	Sex	Hand	Instrument	Technique
P1	8	1	M	R	Drums	T
P2	7	1	F	L	Piano and Drums	T
P3	5	1	M	R	Piano, Guitar, and Drums	T

Table I.1: Participant Demographic. T - Traditional, S - Suzuki

For the results of the first iteration of testing, first we processed the timestamps in order to normalize these values. This is important so we can properly understand the actual time it took them to finish the task, this can be seen in Figures I.1, I.2, and I.3. We then observed that due to other circumstances during the testing like the long duration and fatigue from school, in answering the questions the children sometimes mistook the scales in grading for the difficulty of the tasks. In some tasks they graded it much easier or harder than what we observed as when we double checked and asked them to name the functionality of a specific part, they were mixing up some of the functionality yet still for example give a score of (1) where they fully remembered it. Due to this their initial scores were then cross referenced to the task they were given and if we observed that there was a big difference in the answer and our observation an adjustment of + 1 or - 1 was changed in the scores to balance these out.

The red bar indicates the level of difficulty that the user has chosen for the task. The blue bar indicates the time for their time of completion for the task. To enhance the visualization we scaled the difficulty of 1-4 by multiplying it by 5 and divided their time by 5 so their correlation can be seen more in the graphs.

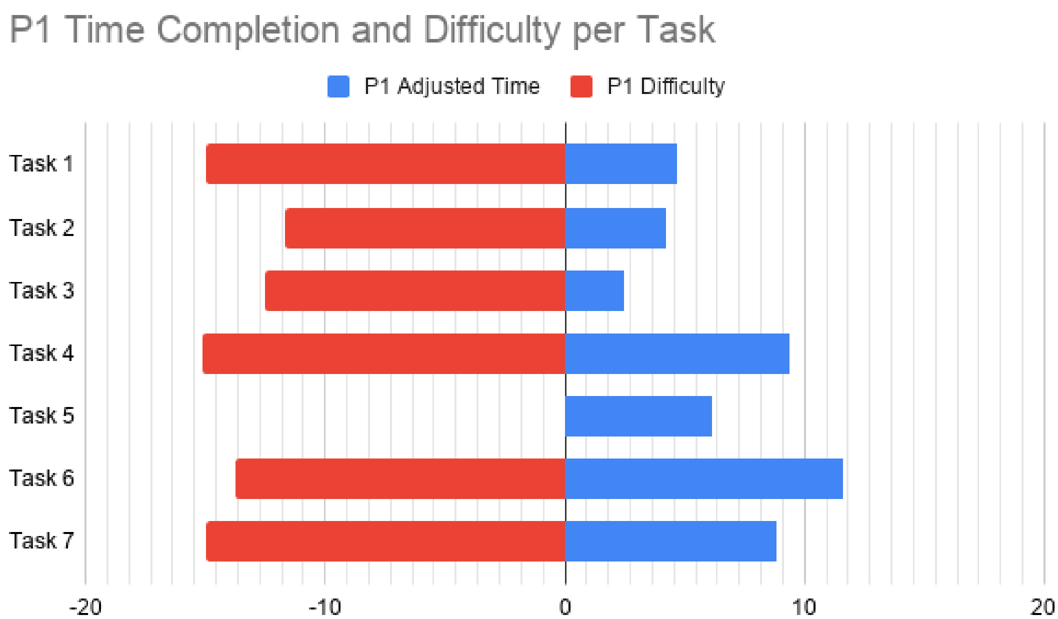


Figure I.1: Time for Completion and Difficulty of Tasks for Person 1

P1 (8, M, Drums) believes that task 4, which was the tail, was most likely not intuitive for him to change because it took him a longer time and he rated it as a higher difficulty compared to playing with the other body parts. Task 6 and 7 took a long time because it was mostly playing around with the application.

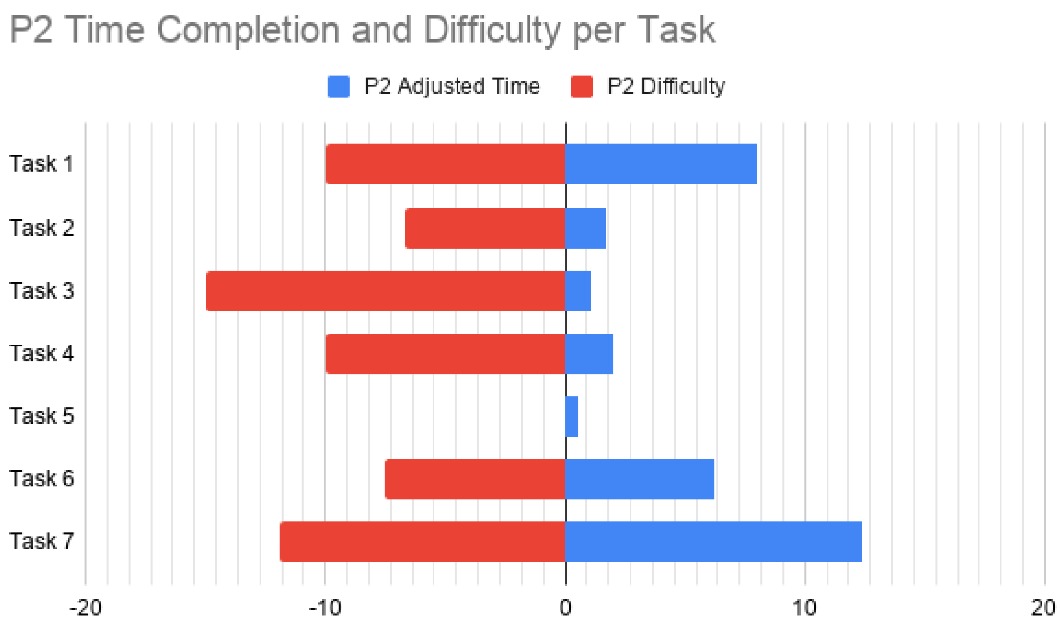


Figure I.2: Time for Completion and Difficulty of Tasks for Person 2

P2 (7, F, Piano) believes that task 2, which is the body, was most likely not intuitive because it took her a long time to complete. It can also be seen also that she did not grade the difficulty as high as person 1 because she has more experience in music.

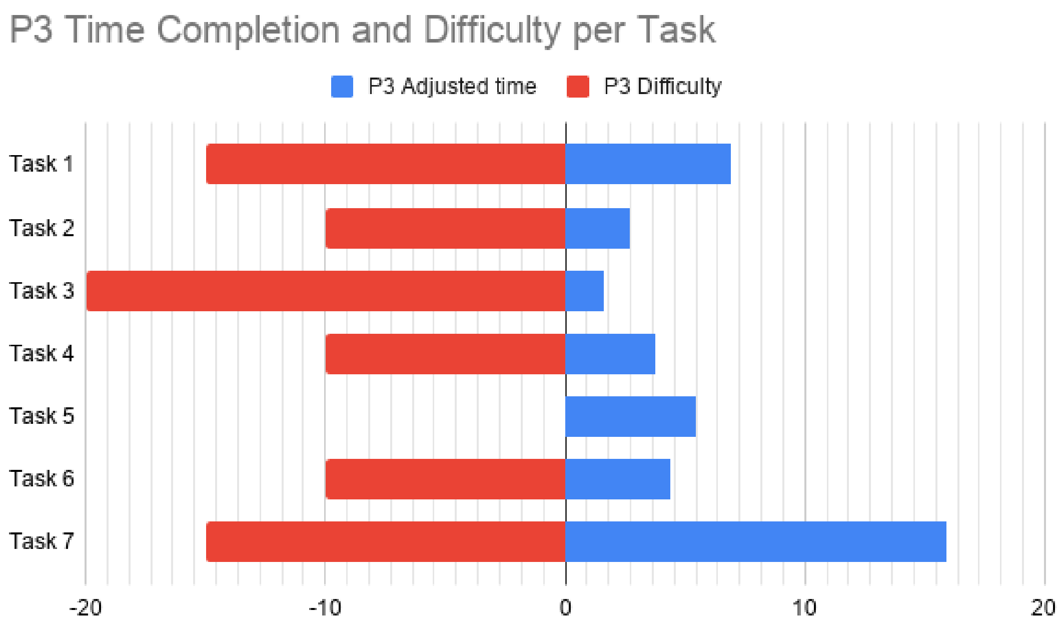


Figure I.3: Time for Completion and Difficulty of Tasks for Person 3

P3 (5, M, Guitar) similar to P2 took a lot of time in performing task 1 which supports that it most likely not intuitive.

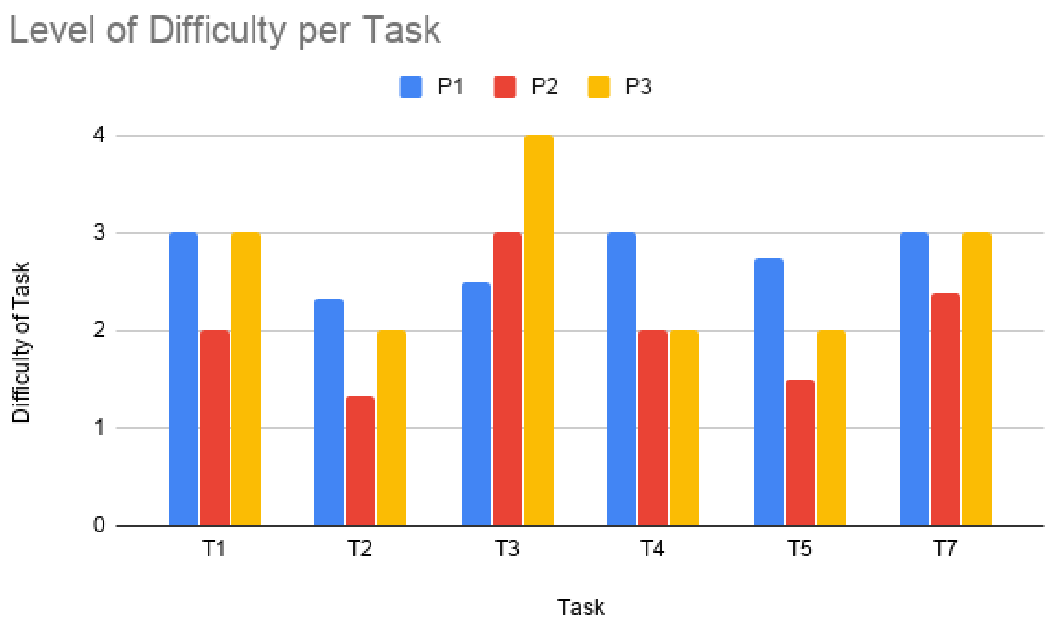


Figure I.4: Difficulty of Tasks for each User

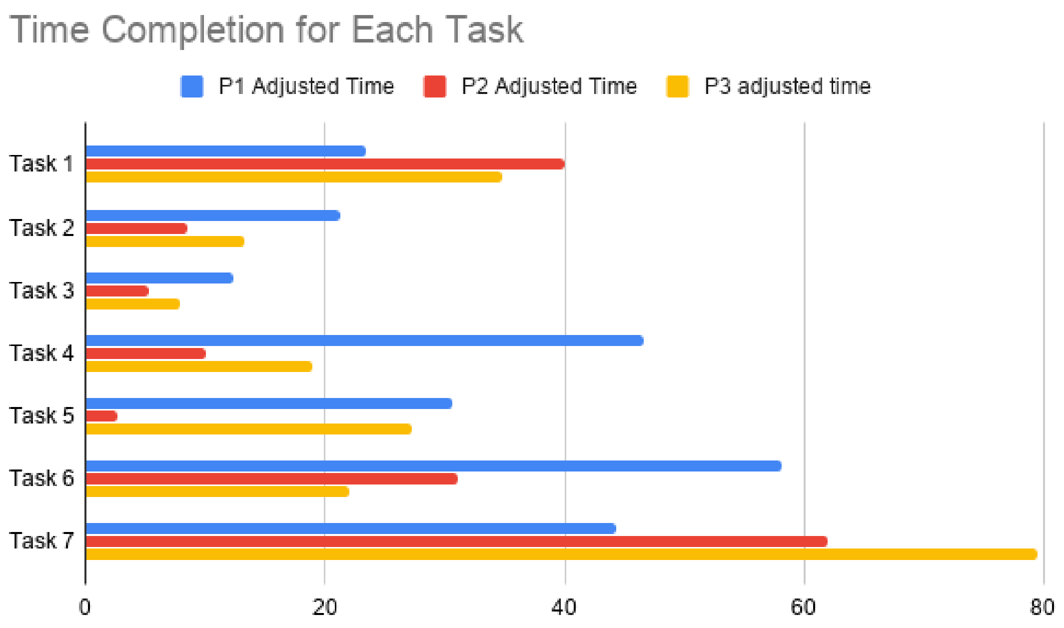


Figure I.5: Time Completion of Tasks for each User

I.1.1 Participant Insights

Figure I.6: Word Cloud of Positive and Negative Comments

I.2 Discussion

It can be seen clearer in Section 4.5 that majority of them took longer in playing with the body part, which is task 1. And upon further observation one of the underlying reasons could be that they tend to miss the hotspot for pressing the body part. We also noticed that most of them would pick their favorite color for the body part, which they enjoyed. It can also be seen that Task 3 which is changing the size of the wings for repetition took them the fastest time to complete

Based on our user testing for iteration one, as seen in Figure I.4, task two, which was to change the speed of the first note using the left wing, took the shortest time to complete and had the lowest difficulty for the users. However, in task two only two out of three users noticed the lever for changing the note to rest or beat. Then task 3, which was to change the number of repetitions by tapping the right wing, took the longest time and had the highest difficulty for the users. We also observed that all participants use their dominant hand most of the time when using the application as P1 and P3 were both right handed as P2 was the only one that was left handed. During the interview some had a hard time remembering which part of the firefly changed each property when they were asked which part did what. The one with most music experience mentioned that the app didn't help much in retaining her music lessons, and then suggested that we utilize a music staff. We observed their behavior when using the application and we noticed that they were eager to explore features that they think is clickable even when the tasks were not yet given to them. We also noticed that in features like the lever, they would use a flick gesture imitating how it is usually used instead of the tap gesture that we set it to be.

As seen in Figure I.6 during testing while they were doing their tasks we took note of their comments and interpreted them in a general way or in terms of a feature that they commented on. The positive comments were represented using cool colors like blue and green, while negative comments were represented with warm colors like red and orange. For the positive comments we observed that aside from us noticing their curiosity in using the application, they themselves say that they are curious when doing their tasks. We can also see that they have comments about being playful and having fun while using the application. In terms of the interface, comments like "Make Sense" and "Engaging" indicated to us that there are features that they like and that some parts of the interface is good for them. For the negative comments, one comment that stood out to us was P3 mentioned that the animations of the firefly was "glitchy", this comment made us improve the assets for the animation for the next animation. The other negative comments like "Looks Funny" and "Distracting" indicated to us that there were some features that they wanted us to change in the interface. Lastly, even if the purpose of the sandbox environment was for the users to play without breaking anything, P3 still said he was "Scared" multiple times to ruin the firefly and we think that this has to do with his young age and also for us to put information on the screen so that the children will not be discouraged to play with the firefly.

Appendix J

Website Screens

J.1 Home Page

FIREFLY-X

Designing Interactions for a Mobile Musical Learning Tool for Children

Home | About | Protocol for Children | Tips | Tasks | Protocol for Music Experts | Consent Forms | Installation Guide | FAQs

About the Research

Welcome to the website of our project FireflyX. This site shall contain relevant information regarding our project, protocol for teachers, and protocol for children.

Research Motivation

1. Teaching children a complex topic such as music is difficult.
2. Children have a shorter attention span and require many repetitions when teaching music.
3. Existing work has its limitations.

PDFmyURL

Call for Participants

We are still in need of participants! If you would like to participate or know anyone who would be interested, please answer this **form**.

Legend and Navigation

1. About- details about the project, team members and their contact info.
2. Protocol for Children - details about the protocol for children.
3. Tasks - details about the tasks children have to do.
4. Protocol for Teacher - details about the protocol for teachers.
5. Consent Forms - shows the collated (and visualized) results from the respondents. Participant info and other identifiers have been removed.
6. Installation Guide - shows the step-by-step process on how to install FireflyX.

FireflyX is maintained by dlsucomet.
This page was generated by GitHub Pages.

PDFmyURL.com - convert URLs, web pages or even full websites to PDF online. Easy API for developers!

J.2 About Page

FIREFLY-X

Designing Interactions for a Mobile Musical Learning Tool for Children

Home | About | Protocol for Children | Tips | Tasks | Protocol for Music Experts | Consent Forms | Installation Guide | FAQs

The Research

The goal of the study is to design and develop a mobile application that children can use to play with and learn music. It hopes to answer the following questions:

- What playful behaviors do children exhibit when composing music?
- What features can be designed to a mobile application tool that enable playful interactions when composing music?
- What behaviors do children exhibit when using a mobile application tool to compose music?

Team Members

Paolo Miguel B. Ato paolo_ato@dlsu.edu.ph

PDFmyURL

Mart Henrick A. Gamutan mart_gamutan@dlsu.edu.ph

Antoine Mikhael M. Salcedo antoine_salcedo@dlsu.edu.ph

Josh Cezar L. Valencia josh_cezar_valencia@dlsu.edu.ph

Jordan Aiko Deja jordan.deja@dlsu.edu.ph

De La Salle University

*Jordan is also affiliated with the University of Primorska

FireflyX is maintained by dlsucomet.
This page was generated by GitHub Pages.

PDFmyURL.com - convert URLs, web pages or even full websites to PDF online. Easy API for developers!

J.3 Protocol for Children Page

FIREFLY-X

This page is for the Protocol for Children

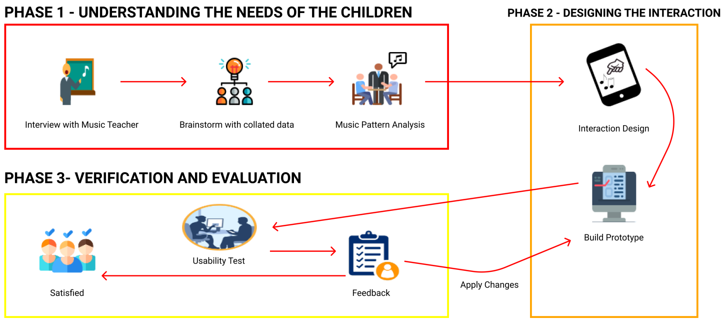
Home | About | Protocol for Children | Tips | Tasks | Protocol for Music Experts | Consent Forms | Installation Guide | FAQs

Overview and Objectives

- We are currently the 3rd stage of our research. We have made 3 versions of the application and in this version we would want to test the learning of the child when the child

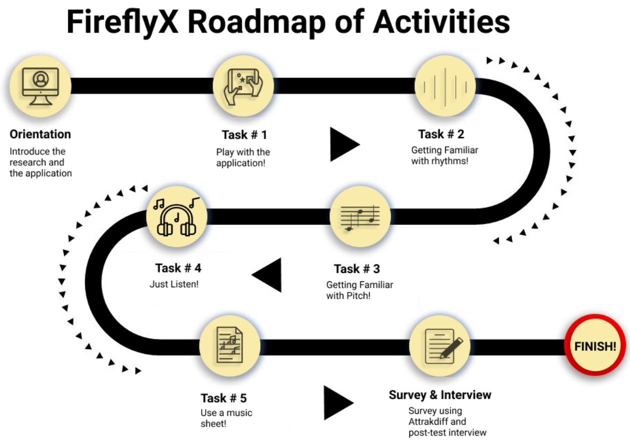
PDFmyURL

accomplishes the 5 tasks to be given.



- For this version of testing we plan to test 6 - 12 children who are aged 5-8 using the application. Ideally, we would like to have a balance between children that enroll in a music school/have experience and also those that are not experienced in music. We would also want a balance between the genders of the participants and a variety in their age.
- Before testing, specific details about the tasks would be explained. It is also advisable that the parents supervise the child so that the order of the tasks will be followed.
- The tasks will be designed in a way that the child will have an audio output that will be given to the music experts for evaluation. We would also explain this more in depth during the online call between us and the children with their parents. The homepage of the application will have 5 different tasks that the child will have to do. Selecting one task would lead to a new screen where they would do their respective tasks.

- Please refer to the **tasks** page to see detailed tasks.



FireflyX is maintained by dlsucomet.
This page was generated by GitHub Pages.

PDFmyURL.com - convert URLs, web pages or even full websites to PDF online. Easy API for developers!

J.4 Tips Page

FIREFLY-X

This page is for tips of how to use FireflyX

Home | About | Protocol for Children | Tips | Tasks | Protocol for Music Experts | Consent Forms | Installation Guide | FAQs

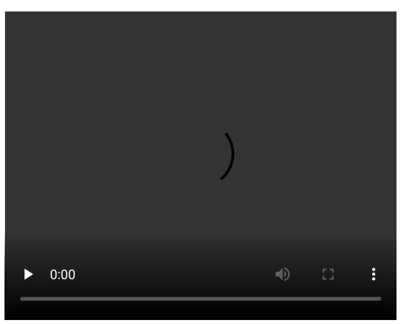
Demo Guide

The Alphabet Song Music Sheet

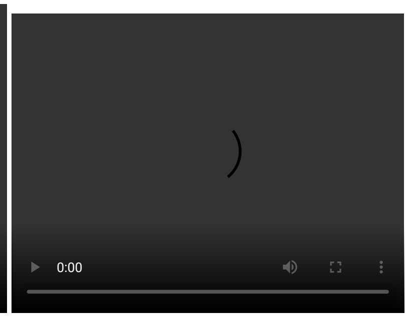
PDFmyURL

THE ALPHABET SONG

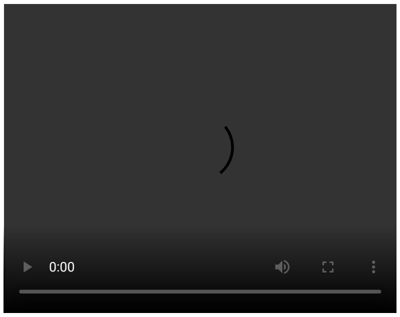
Jar 1 Video Guide



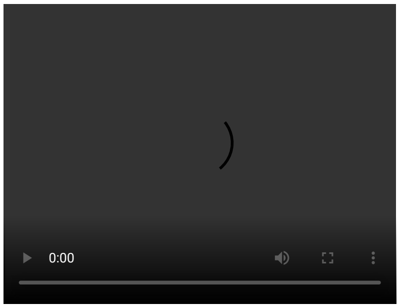
Jar 1 Firefly Playback Output



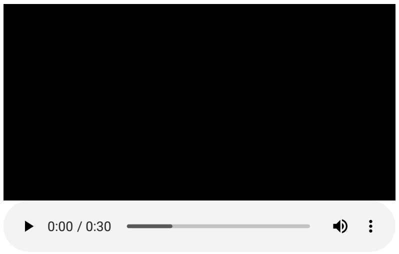
Jar 2 Video Guide



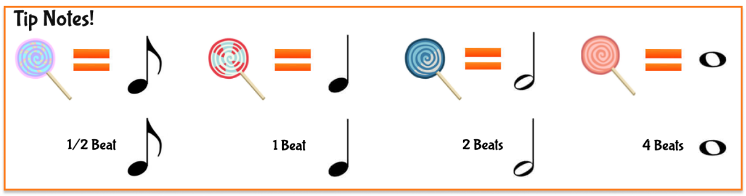
Jar 2 Firefly Playback Output



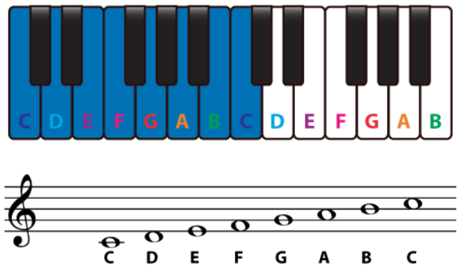
Audio of both jars in succession



Music Reading Tips



C Major Scale



FireflyX is maintained by dlsucomet.
This page was generated by GitHub Pages.

PDFmyURL.com - convert URLs, web pages or even full websites to PDF online. Easy API for developers!

J.5 Tasks Page

FIREFLY-X

This page is a guide for the tasks

Home | About | Protocol for Children | Tips | Tasks | Protocol for Music Experts | Consent Forms | Installation Guide | FAQs

Task 1: Play Around!

- Explore the features of the application (make simple sounds like DoReMi)

Task 2: Getting Familiar with Rhythm!

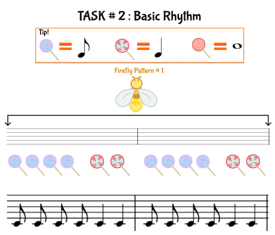
- For this task we will be giving the child this simple rhythm as seen below, for this specific task there will be no pitch present and all beats will be set in C.
- Let the child listen to the music.
- The song can be heard by accessing the mp3 file below.
- Examples will be given to help the child see what to do. These pictures are arranged in order from left to right, then top to bottom. (Check pictures below)

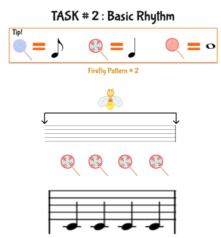
PDFmyURL

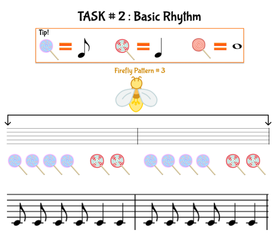
- Copy the rhythm as best as you can!

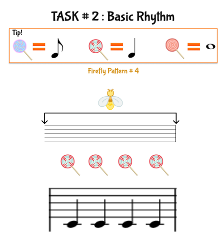
Basic Rhythm Sheet

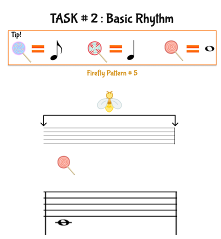
Basic Rhythm Tips



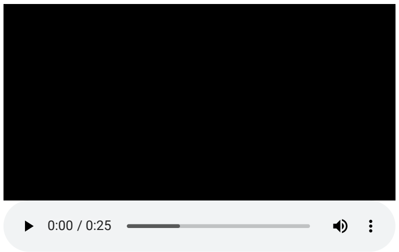








Task 2 Audio



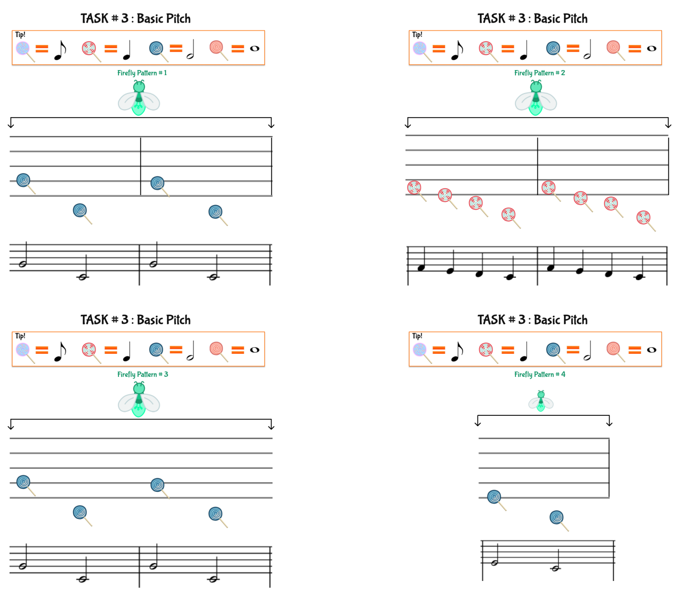
Task 3: Getting Familiar with Pitch!

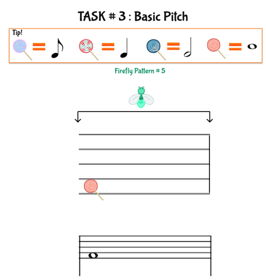
- Same as the previous task, but with the song called “Bells in the Snow” with repeating sections as seen below.

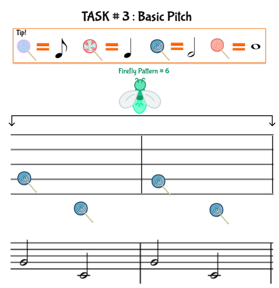
- This task will require the child to explore more features of the application due to pitch being added and more sections of the songs can be seen.
- Let the child listen to the music.
- The song can be heard by accessing the mp3 file below.
- Examples will be given to help the child see what to do, but this time with music sheets. These pictures are arranged in order from left to right, then top to bottom. (Check pictures below)
- Copy the rhythm with pitch as best as you can!

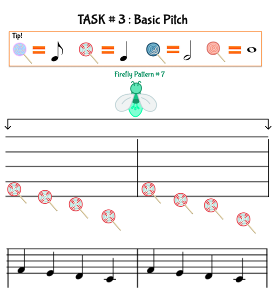
Basic Pitch Sheet

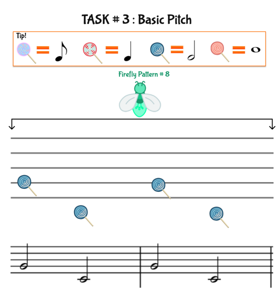
Basic Pitch Tips

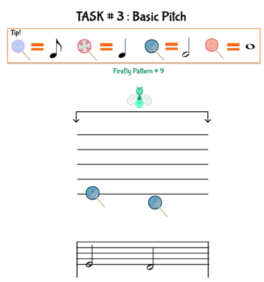

TASK # 3 : Basic Pitch
Tip!
Firefly Pattern # 1
TASK # 3 : Basic Pitch
Tip!
Firefly Pattern # 2
TASK # 3 : Basic Pitch
Tip!
Firefly Pattern # 3
TASK # 3 : Basic Pitch
Tip!
Firefly Pattern # 4


TASK # 3 : Basic Pitch
Tip!
Firefly Pattern # 5


TASK # 3 : Basic Pitch
Tip!
Firefly Pattern # 6

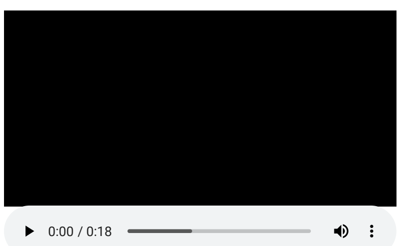

TASK # 3 : Basic Pitch
Tip!
Firefly Pattern # 7

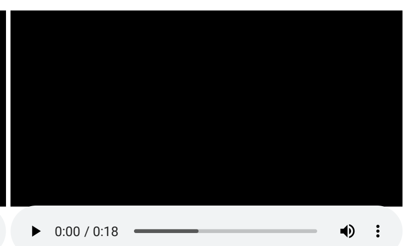

TASK # 3 : Basic Pitch
Tip!
Firefly Pattern # 8



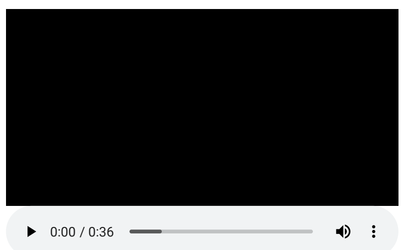
Task 3 First Jar Audio

Task 3 Second Jar Audio





Task 3 Audio of both jars in succession

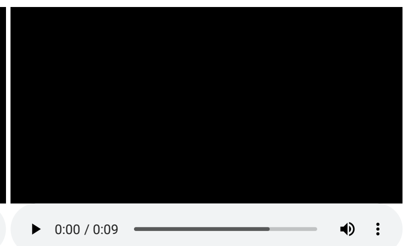


Task 4: Remaking a song!

- Recreate part of the song with only a music sheet (Twinkle, twinkle, little stars).
- For this task, the child will be asked to compose the song using the music sheet while listening to the song.
- There is no more visual assistance from the firefly to help you compared to task 2 and 3, as they will be using the music sheet provided below and the song to compose the music sheet.
- The song can be heard by accessing the mp3 file below.

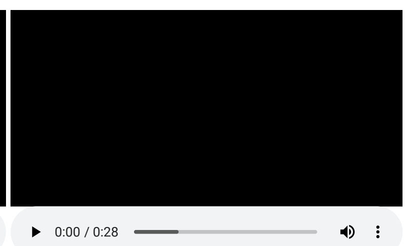
Twinkle Twinkle Little Star Jar 1 Audio

Twinkle Twinkle Little Star Jar 2 Audio



Twinkle Twinkle Little Star Jar 3 Audio

Twinkle Twinkle Little Star Audio



Task 5: Just Listen!

- Recreate a small part of 'London Bridge is Falling Down' without the assistance of a music sheet.
- For this last task we will let the child compose a short and very familiar song, we will be requiring the child to try to copy it with the best of their abilities with them only listening to what it should sound like.
- The song can be heard by accessing the mp3 file below.

London Bridge is Falling Down Audio

0:00 / 0:09

FireflyX is maintained by dlsucomet.
This page was generated by GitHub Pages.

PDFmyURL.com - convert URLs, web pages or even full websites to PDF online. Easy API for developers!

J.6 Protocol for Music Experts Page

FIREFLY-X

This page is for the Protocol for Music Experts

Home | About | Protocol for Children | Tips | Tasks | Protocol for Music Experts | Consent Forms | Installation Guide | FAQs

Protocol for Music Experts

- After the children have completed their tasks in testing, each child will have a song output from the tasks that they have done.
- The sequence of the tasks that were done can be seen in the Tasks page, this is to be used in gauging if there was an improvement in the compositions that were made by the kids.
- The music samples that they have done will then be forwarded to music experts for them to comment on the learning that the child has done throughout the different days of using the application. We will personally be giving these music samples in a google drive to each music expert with the identity of each child anonymized. We will also be giving information about the child's experience in regards to music.

PDFmyURL

- Aside from this the music experts will be given the expected sound of the song with the corresponding music sheet in tasks that they were required to copy a particular song.
- Music Experts are asked to fill out this **form**

More details to come soon!

FireflyX is maintained by dlsucomet.
This page was generated by GitHub Pages.

PDFmyURL.com - convert URLs, web pages or even full websites to PDF online. Easy API for developers!

De La Salle University

J.7 Consent Form Page

FIREFLY-X

This page is for the Consent Forms

Home | About | Protocol for Children | Tips | Tasks | Protocol for Music Experts | Consent Forms | Installation Guide | FAQs

Consent Forms

Consent forms could be accessed here **Parental Consent Form**

More details to come soon!

FireflyX is maintained by dlsucomet.
This page was generated by GitHub Pages.

PDFmyURL

J.8 Installation Guide Page

FIREFLY-X

This page is a step-by-step guide on how to install FireflyX.

Home | About | Protocol for Children | Tips | Tasks | Protocol for Music Experts | Consent Forms | Installation Guide | FAQs

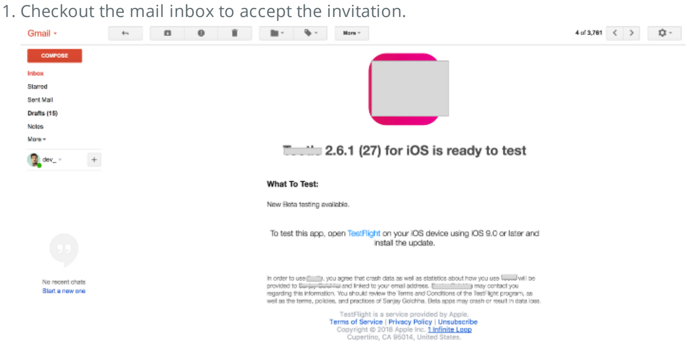
Always remember to

1. Update iOS to the latest version.
2. Update Testflight to the latest version.
3. Update FireflyX to the latest version.

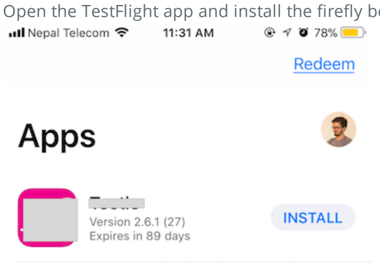
How to install the application:

PDFmyURL

1. Checkout the mail inbox to accept the invitation.



2. Install the TestFlight App from the app store.
3. Open the TestFlight app and install the firefly beta app.



4. You can now use FireflyX! Head over to **tasks** to check out the tasks or to **tips** to learn more on how to use the app!

FireflyX is maintained by dlsucomet.
This page was generated by GitHub Pages.

PDFmyURL.com - convert URLs, web pages or even full websites to PDF online. Easy API for developers!

J.9 FAQ Page

FIREFLY-X

This page is for the Protocol for Music Experts

Home | About | Protocol for Children | Tips | Tasks | Protocol for Music Experts | Consent Forms | Installation Guide | FAQs

Frequently Asked Questions (FAQs)

Will my child be safe?

- Yes, your child's safety is our **utmost priority**. Your data shall be **stored securely** and not shared with anyone that has no involvement in the study.

Will my child's face be recorded?

- Your child's face will **only** be recorded if you consent to allowing us to record your child's face.

PDFmyURL

How will my child's data be used?

- Your child's data will be used to identify how effective our app is in teaching children. The tasks done by your child is **not** a measure of how good your child is, rather it is a measure of effectivity of the app.

Will the sessions be recorded?

- The sessions will only be recorded **only** if you consent to being recorded.

How many sessions will there be?

- The number of sessions will depend on **how fast** the child can accomplish the tasks.

Can I assign someone to supervise my child if I am not available?

- The parent **can assign any other guardian** if they are not available during the testing date.

How long do the sessions take?

- They usually take around **1 hour** to finish.

More details to come soon!

FireflyX is maintained by dlsucomet.
This page was generated by GitHub Pages.

PDFmyURL.com - convert URLs, web pages or even full websites to PDF online. Easy API for developers!