FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

A Collaborative Musical Composition Platform for Children, by Children

Ricardo Filipe Teixeira Gonçalves

Mestrado Integrado em Engenharia Informática e Computação

Supervisor: Ademar Manuel Teixeira de Aguiar (PhD)

Co-supervisor: Paula Alexandra Gomes da Silva (PhD)

Co-supervisor: Rui Rocha Melo (MSc)

23rd January of 2012

A Collaborative Musical Composition Platform for Children, by Children

Ricardo Filipe Teixeira Gonçalves

Mestrado Integrado em Engenharia Informática e Computação

Approved in oral examination by the committee:

Chair: Doctor Luís Filipe Pinto de Almeida Teixeira

External Examiner: Doctor Joaquim Melo Henriques Macedo

Supervisor: Doctor Ademar Manuel Teixeira de Aguiar

23^{rd} January of 2012

Abstract

Music is such a big part of our lives that a world without it is unimaginable. Musical intelligence is as important as other types of intelligence, such as logical and linguistic. However, the Portuguese educational system does not reflect this. The creative subjects that stimulate the children's mind, such as music, are constantly overshadowed by others that are considered more important by society, and there are no changes at sight. Today, technology allows the creation of engaging interactive experiences, giving us the opportunity to stimulate children in novel ways. With the dissemination of computers in our households, children can be reached in ways the educational system cannot.

This dissertation proposes the creation of a collaborative musical composition platform for children, with the goals of stimulating their interest in music and developing their musical intelligence. This work was developed in the context of a Research & Development project, called *Creative Schools*, whose goal is add the support for the creation of digital media to *schoooools.com*, a collaborative learning environment where children aged between 4-12 years old can create their own texts, drawings and media, and safely share, communicate and collaborate with their teachers and parents.

The creation of something that stimulates the children's mind, engaging them in learning activities and developing their (musical) intelligence is far from easy. First, we need to understand how children, or people in general, learn. Therefore, this work's theoretical foundations are supported by several theories of cognitive development, in order to make sure that we create an environment where children can explore and learn the musical universe on their own. Second, we must engage children in this activity. Therefore, collaboration was introduced, not only for engagement purposes, but also to support the learning process, through group learning.

When designing for children, we must take in account that, although we have been through childhood, we do not know what is best for them. To create something tailored to children's needs and interests, one needs to work closely with them.

This dissertation describes how a collaborative musical composition platform was built by including children in the design team as partners, where they contribute to the solutions directly. To use this approach, a custom methodology adapted to the requirements and constraints of this dissertation has been developed. The application of this methodology results in a semi-functional prototype, that serves as proof of concept for the proposed platform.

Resumo

Sendo a música uma parte tão grande das nossas vidas, é inimaginável viver num mundo sem ela. A importância da inteligência musical é tão grande quanto outros tipos de inteligência, como lógica ou a linguística. Contudo, o nosso sistema educativo não reflecte isto. As disciplinas criativas que estimulam a mente das crianças, como a música, são ofuscadas por disciplinas que são percebidas como mais importantes pela sociedade, e a mudança não está à vista. A tecnologia permite-nos criar experiências interactivas envolventes, criando a oportunidade de estimular as crianças de formas inovadoras. Com a disseminação dos computadores nas nossas casas, é possível chegar às crianças de maneiras que o sistema educativo não pode.

Esta dissertação propôe a criação duma plataforma de composição musical colaborativa para crianças, cujos objectivos são estimular o seu interesse pela música e desenvolver a sua inteligência musical. Este projecto foi desenvolvido no contexto dum projecto de investigação e desenvolvimento chamado Escolinhas Criativas, cujo objectivo é permitir a criação de *media* digitais ao *Escolinhas*, um ambiente de aprendizagem colaborativa onde crianças com idades entre os 4 e os 12 anos podem criar textos, desenhos e *media*, e, com segurança, partilhar, comunicar e colaborar com os seus professores e pais.

A criação de algo que estimula a mente das crianças, de forma a envolvê-las em actividades de aprendizagem, e que desenvolve a sua inteligência musical está longe de ser fácil. Primeiro, necessitamos de compreender como é que as crianças, ou as pessoas em geral, aprendem. Portanto, as bases teóricas deste trabalho são suportadas por várias teorias de desenvolvimento cognitivo, de forma a garantir que criamos um ambiente onde as crianças, por si, consigam explorar e aprender o universo musical. Em segundo lugar, necessitamos de envolver as crianças nestas activiades de aprendizagem. Para responder a isto, foi introduzida a colaboração, não só para envolver as crianças nas actividades, mas também para suportar o processo de aprendizagem através de aprendizagem em grupo.

Apesar de todos termos passado pela infância, quando estamos a criar algo para crianças é importante ter em conta que não sabemos o que é realmente importante considerar. Para criar algo adaptado às necessidades e interesses das crianças.

Esta dissertação descreve como é que foi criada uma plataforma de composição musical incluindo crianças no processo de desenho, assim contribuindo directamente para a soluçãodirectamente. Para usar esta abordagem, foi criada uma metodologia costumizada aos requisitos e restrições desta dissertação. A aplicação desta metodologia resulta num protótipo semi-funcional, que serve como prova de conceito para a solução a ser proposta.

Acknowledgements

I would like to thank everyone who contributed to this thesis in some way, especially: my supervisors Ademar Aguiar, Paula Silva and Rui Melo, who provided me great guidence and support; the great people at *Tecla Colorida* for all the feedback and ideas and for integrating me on the company as one of theirs; and both the schools that opened their doors to this project - *Escola EB1/JI de Cabanelas* and *Escola EB1/JI de Magarão* - represented by Professor Mónica Rodrigues and Professor Fernando Araújo, respectively.

However, this thesis is the end of a long and arduous path, and all the credits go for the ones who supported me throughout: my father, my mother, my brother, my girlfriend and all my family. Thank you.

Ricardo Filipe Teixeira Gonçalves

Contents

1 Introduction **1**
1.1 Motivation . . . 2
1.2 A collaborative musical composition platform for children, by children . . . 2
1.3 Dissertation outline . . . 4

2 How children learn (and how can we learn about them) **5**
2.1 Theories of cognitive development . . . 5
2.1.1 Teacher-centered: behaviourism and cognitivism . . . 6
2.1.2 Learner-centered: constructivism and constructionism . . . 7
2.1.3 Group-centered: social constructivism . . . 8
2.1.4 Summary . . . 9
2.2 Collaborative learning through technology . . . 9
2.3 Creating an engaging experience . . . 10
2.3.1 Being involved with something in an attempt to understand it . . . 11
2.3.2 Being involved with something with someone in an attempt to understand it 11
2.3.3 Summary . . . 11
2.4 Exploring music . . . 11
2.5 Understanding the relation between children and computers . . . 12
2.5.1 Human-computer interaction . . . 13
2.5.2 Child-computer interaction . . . 14

3 Designing for children, with children **15**
3.1 Children in the design process . . . 15
3.2 Design methodologies to work with children . . . 17
3.2.1 Cooperative Inquiry . . . 18
3.2.2 Mixing Ideas . . . 19
3.2.3 (Modified) Layered Elaboration . . . 20
3.2.4 Informant Design . . . 21
3.2.5 KidStory . . . 22
3.2.6 Bluebells . . . 23
3.2.7 CARSS - Context, Activities, Roles, Stakeholders and Skills . . . 24
3.3 Summary . . . 26

4 Music tools for children **29**
4.1 Non-collaborative music-related tools . . . 29
4.1.1 Hyperscore . . . 29
4.1.2 Groovy City . . . 30
4.1.3 San Francisco Kids . . . 31

4.1.4 FlexiMusic Kids Composer 32
4.1.5 Toons Tunes 32
4.1.6 Isle of Tune 33
4.1.7 DrumSteps 34
4.2 Collaborative music-related tools 35
4.2.1 Team Composer 35
4.2.2 jam2jam 35
4.2.3 Daisyphone 37
4.2.4 MOGClass 38
4.3 Summary 38

5 Research problem and methodology 41
5.1 Problem definition and contributions 41
5.2 Design methodology 42
5.2.1 Requirements 43
5.2.2 A Rigidly Flexible methodology 44
5.2.3 Summary 47

6 Understanding the children's perspective 49
6.1 How do children perceive music? 49
6.1.1 Interviews with children 50
6.1.2 Pictorial expression 52
6.1.3 Conclusion 53
6.2 How do teachers see education, music and technology? 54
6.3 How do children collaborate to interact with technology? 56
6.4 Results 58

7 Solving the problem, alongside children 61
7.1 Defining the microworld 62
7.2 Defining the requirements 65
7.3 Designing the platform 68
7.3.1 How do you do that? 68
7.3.2 I do not want to be a dummy! 69
7.4 Tying the loose ends 71
7.5 Summary 72

8 Prototype design and evaluation 73
8.1 The first prototype 73
8.1.1 Requirements 74
8.1.2 Prototype 75
8.2 Evaluation session #1 78
8.2.1 Introduction 78
8.2.2 Results 79
8.2.3 Iteration 80
8.3 Evaluation session #2 83
8.3.1 Introduction 83
8.3.2 Results 84
8.3.3 Iteration 85
8.4 Evaluation session #3 89

8.4.1 Introduction . . . 89
8.4.2 Results . . . 90
8.5 Summary . . . 91

9 Results and discussion 93

10 Conclusions 97
10.1 Future work . . . 97
10.2 Dissemination of the work . . . 98
10.2.1 Scientific dissemination . . . 98
10.2.2 Industrial dissemination . . . 98

References 101

A Full session scripts and results 107
A.1 Research activities . . . 107
A.1.1 Interviews with children . . . 107
A.1.2 Pictorial expression . . . 109
A.1.3 Interviews with teachers . . . 110
A.1.4 Technology immersion . . . 111
A.2 Design activities . . . 112
A.2.1 Creating the instrument of the future . . . 112
A.2.2 "You should be able to..." . . . 113
A.2.3 How would you do that? . . . 115
A.2.4 "I don't want to be a dummy!" . . . 116
A.3 Evaluation sessions . . . 116
A.3.1 Evaluation session #1 . . . 116
A.3.2 Evaluation session #2 . . . 117
A.3.3 Evaluation session #3 . . . 119

B Personas 123
B.1 Student #1: Bernardo Sousa . . . 123
B.2 Student #2: Maria Carvalho . . . 124
B.3 Student #3: Rui António . . . 124
B.4 Teacher: Manuela Araújo . . . 125

C Paper submited to the Interaction Design and Children 2012 conference 127

CONTENTS

List of Figures

3.1 Roles of children in the design proccess [Dru02] 16

4.1 An example of Hyperscore's canvas [Lin11] 30
4.2 Groovy City's creation mode [Sib11] 30
4.3 Learning with San Francisco Kids [Sym11] 31
4.4 An example of FlexiMusic Kids Composer's canvas [Fle11] 32
4.5 Toons Tunes' mix-o-matic [Tun11] 33
4.6 An example of an Isle of Tune island [oT11] 34
4.7 An example of DrumSteps' canvas [JT01] 35
4.8 An example of Team Composer's canvas [San10] 36
4.9 OLPC Laptop running jam2jam XO [Chi11] 36
4.10 An example of Daisyphone's canvas [BK09] 37
4.11 MOGClass interface for students [ZPW$^+$10] 38

5.1 Diagram of the methodology 45

6.1 Examples of the drawings produced in the Pictorial expression activity 53

7.1 Some results of the Creating the instrument of the future activity 64
7.2 Some results of the Defining the requirements session 65
7.3 First sketch of the microworld concept 67
7.4 First sketch of the microworld concept - detail of a dance move 67
7.5 Some results of the How do you do that? session 69
7.6 Some results of the I do not want to be a dummy! session 70

8.1 Dance move editor prototype 76
8.2 Example of a dance move sequence 77
8.3 Prototype subject to evaluation 79
8.4 The interaction evaluated on the Evaluation session #1 80
8.5 Samples of the running prototype 81
8.6 Dance stage 82
8.7 Interaction with the dance stage, if the player did not create moves 83
8.8 Interaction with the dance stage, if the player created moves 83
8.9 Iterated dance move editor 86
8.10 Iterated dance move editor - detail of a sequence being played 86
8.11 Iterated dance stage 87
8.12 Iterated dance move editor 88
8.13 Iterated dance move editor 88
8.14 The interaction evaluated on the Evaluation session #3 89

8.15 Continuation of the interaction evaluated on the Evaluation session #3 90
8.16 Continuation of the interaction evaluated on the Evaluation session #3 90

List of Tables

3.1 Overview of the methodologies described in 3.2 26

A.1 Results of the second evaluation session 120
A.2 Results of the third evaluation session 121

LIST OF TABLES

Abbreviations

ACM	Association for Computing Machinery
API	Application Programming Interface
CCI	Child-Computer Interaction
CSCW	Computer Supported Collaborative Work
CSCL	Computer Supported Collaborative Learning
CSS	Cascading Style Sheets
HCI	Human-Computer Interaction
HTML	Hypertext Markup Language
I/O	Input/Output
INESC	Instituto de Engenharia de Sistemas e Computadores
ISEP	Instituto Superior de Engenharia do Porto
PD	Participatory Design
SIGCHI	Special Interest Group on Computer Human Interaction
TV	Television
WWW	World Wide Web
UCD	User-Centered Design
UX	User Experience
ZPD	Zone of Proximal Development

Chapter 1

Introduction

The evolution of technology and the increasing number of children using computers, created many new opportunities to stimulate children's intellectual development at younger ages through engaging, interactive and innovative experiences. There have been some serious efforts to introduce technology in classrooms to aid the learning experience, using it as an learning tool [dE11]. Usually, these efforts have been directed to support the traditional methods of teaching, for example helping students grasp complex concepts. However, as Seymour Papert stated, the classroom is "an artificial and inefficient learning environment that society has been forced to invent because its informal environments fail in certain essential learning domains, such as writing or grammar or school math" [Pap93].

Music is such a big part of our lives that a world without it is unimaginable. Learning music theory is far from easy, and it takes both dedicated students and teachers to do it with success. However, such formal education is not needed to create music, the same way a child does not need a degree in Painting to know how to draw a picture. In a study about children's practice of computer-based musical composition, Nilsson and Folkestad conclude that "young children without formal education are able to create music with form and structure" [NF05]. Although formal education is essential later on, introducing it so early can create a gap between the student and the creative process, demotivating the student. When painting, a child can produce a piece of art with just a blank sheet of paper and a set of crayons. In the end, the child has an object, a piece of art, one that he can show to others, opening discussion that can even lead to improvement. However, when talking about music creation, this process is not quite the same, not to say more difficult. Although a child can make music from virtually anything, it is substantially more expensive to offer the child a set of tools, even the ones specifically made for music education, that allows him to express his creativity. This usually translates into less opportunities for the student to explore the musical universe.

How can we create an engaging music composition tool that provides an unique learning experience?

1.1 Motivation

> "The art of music is so deep and profound that to approach it very seriously only is not enough. One must approach music with a serious rigor, and, at the same time, with a great, affectionate joy."
>
> Nadia Boulanger - French Composer, conductor and teacher

There are several studies in the literature that state the importance of the development of musical intelligence in an early age [Gar83] [Arm94] [PD87] [LM88] [Lev98]. Howard Gardner, a Harvard psychologist, states that "music intelligence is equal in importance to logical-mathematical intelligence, linguistic intelligence, spatial intelligence, bodily-kinesthetic intelligence, interpersonal intelligence, and intrapersonal intelligence" [Gar83]. However, in my experience, the effort in the development of musical intelligence in Portugal is not anywhere near the same as the development of other capabilities, such as mathematical or linguistic.

One of my motivations to develop this project is a personal one. I did not find my own music education engaging. Independently of the quality of that education, I believe that it was not engaging enough to motivate me to explore this area further.

Later on, when I naturally became interested in music, I had to feed my hunger for musical knowledge on my own, through whatever means I had available. Growing up in a generation that has had early contact with technology, I had the good fortune of having easy access to software tools of music composition and editing. However, the available tools were: i) too powerful, suited for professionals; ii) too limited, giving no room for exploration. We can see that the scenarios are the opposite from each other, where in one hand we have a complex tool with a steep learning curve, for a child, and on the other hand a limited tool, arguably made for the masses, that was not challenging enough. However, both the scenarios have one common point: both are unmotivating, each in its own way.

That said, I believe that by empowering children with the right tools of exploration, we can engage them in sessions of musical improvisation and exploration that teach them more about music than formal learning methods, just like I did when I was a child.

1.2 A collaborative musical composition platform for children, by children

What this thesis proposes, in one sentence, is an **online platform** that will allow children to **compose music**, **collaboratively**, through an exploratory environment, with the goals of **stimulating** their interest in music, while **learning** some of the foundations of music theory.

This problem, in order to be solved, has to be decomposed in several sub-problems: i) **cognitive development** theories need to be explored, to understand how people learn; b) the relation between **collaboration and technology** will be studied, to learn how we can use both to improve learning; and iii) the study of the characteristics that could make this tool **engaging** for children, so that they immerse themselves in this universe.
These problems will be addressed separately, even though they have common points, in chapter 2: How children learn (and how can we learn about them).

But first, it is important to contextualize **where** this project is going to be developed, the **vehicle** where children will be able to use it, and its **target audience**.

The project being developed in the context of this dissertation belongs to a much larger project named *Creative Schools* (loosely translated from *"Escolinhas Criativas"*). The goal of *Creative Schools* is to bring multimedia to the online community based on *schoooools.com* platform [Col10], where students, teachers and parents can create, collaborate, communicate and share, giving children, **aged four to twelve**, the opportunity to engage in the Web 2.0 and the new digital media world in a learning context [Esc11].

Schoooools.com can be divided in three key components [Val11]: educational, recreational and social. In its educational component, children can create essays, in collaboration with their teachers, containing text, drawings, images, videos, maps and files. In its recreational component, the platform offers several educational games, as well as tools to multimedia resources. Finally, in its social component, the students can communicate as well as collaborate with their colleagues, teachers or parents in several activities.

Creative Schools resulted from a collaboration between *Tecla Colorida*, the company behind *schoooools.com*, and several entities, including *INESC Porto*, a non-profit investigation center focused on technology [Por11], the *University of Porto* [dP11], *ISEP*, the Engineering Institute of Porto [dEdP11], the *University of Minho* [dM11] and local schools, notably *Colégio Paulo VI* [VI11].

Essentially, this project has the goal of providing new functionalities on the area of new digital media to schoooools.com, giving students the opportunity to explore creatively several facets of this area, like audio, video, animation, TV on the web, and others [Col10].

The context of this project, being schoooools.com a web platform, defines the medium where it will be presented: the **web browser**. That said, children will experience this platform on their computers, or their school's computers. However, there is one more project I must mention. In 2005, the Portuguese government approved a set of measures that aimed to modernize the country

[dE11]. One of this measures, called *e-escolinhas*, gave the opportunity for children in elementary schools to acquire a portable computer at very reasonable price, from 0 to 55 Euros [dE11].

Since *schoooools.com* and *e-escolinhas* target audience intersect, hence corresponding with the target of this project, I must consider the technological capabilities of this low-cost portable computer.

Another important point is that my target audience is automatically defined by schoooools.com. **The target of this platform is children aged between 4-12 years old attending elementary school**.

1.3 Dissertation outline

This document is divided into ten chapters:

1. The first chapter, Introduction, the one you are reading now, contextualizes this work, defines the problem and explains the author's motivations into solving it.
2. The second chapter, How children learn (and how can we learn about them), contains a literature review of the areas surrounding the problem.
3. The third chapter, Designing for children, with children, presents a study in the current trends of working with children.
4. The fourth chapter, Music tools for children, explores the most relevant tools in the market that address similar problems of music education as the one being addressed in this dissertation.
5. The fifth chapter, Research problem and methodology, defines the problem based on the literature review and presents the research methodology that was used.
6. The sixth chapter, Understanding the children's perspective, explains the research activities that took place in this dissertation.
7. The seventh chapter, Solving the problem, alongside children, is the core chapter of this dissertation, detailing the activities that took place to design the platform, alongside children.
8. The eigth chapter, Prototype design and evaluation shows how the prototype was iterated based on successive evaluation sessions.
9. The ninth chapter, Results and discussion discusses the positive and negative aspects of this work, as well as the results.
10. The tenth and final chapter, Conclusions, closes this dissertation by discussing the work that needs to be done in the future and how this work is going to be disseminated.

Chapter 2

How children learn (and how can we learn about them)

As Allison Druin states, and as obvious as it may seem, we all have been through childhood. Due to the memories of the experiences we have been exposed to, we have preconceived notions of things and how they work [Dru02]. Regarding education, due to these preconceived notions, we think that we know what is right and what is wrong on how we learn best, and how we can improve this learning process. However, the pitfalls of trusting these preconceived notions must be avoided, as they can limit our vision, being based solely on our experiences in how learning might be improved. Another pitfall is asking teachers and parents about children's needs [Dru02]. While it might give extremely useful insights, when building technology for children that is certainly not the (only) way to go.

Learning is a complex equation, and every variable must be addressed carefully. This chapter is going to address the topics that allow a good understanding of the problems stated in Chapter 1, in order to provide a solution that fits children's needs and desires. The following sections will present **theories of cognitive development**, how **learning can occur in a collaborative environment**, the **importance of an engaging experience**, some important **definitions in musical concepts** and how we can **gain insights in building the right tool for children**.

2.1 Theories of cognitive development

The importance of taking in account how children learn has and will be stated several times throughout this document. To address this topic, an overview of the theories of cognitive development most relevant to this dissertation will be given: Behaviourism, Cognitivism, Constructivism, Constructionism and Social Constructivism. A bigger emphasis will be on the last three, since they are, arguably, the most influential tendencies on how we teach children.

2.1.1 Teacher-centered: behaviourism and cognitivism

In a nutshell, **behaviourism** states that every reflex to the environment is a behaviour, ignoring the cognitive processes.

Ivan Pavlov, a Russian physiologist, noticed that his dogs salivated whenever it smelled like food at feeding time. As an experiment, whenever those two events happened, he rang a bell, doing this everyday for a long time. One day, without any food, he rang the bell. He noticed that the dogs were salivating, even though there was no food. He called this phenomenon Conditional Reflexes, the foundation of behaviourist theories.

Without going into detail, an overview of the two most cited approaches - i) classic conditioning; and ii) operant conditioning - follows.

Behaviourism *per se* was only introduced in 1913 by John Broadus Watson. Based in Pavlov's work, he proposed classic conditioning, a process that he claims it explains all human behaviour [Wat13]. Classic conditioning simply states that everything is a reaction to a stimulus, disregarding the mental processes.

Where classic conditioning states that a response is a reaction to a stimulus, operant conditioning reverts the process, stating that the likelihood of a response to happen again depends of its consequence [HH97]. In other words, a third variable enters the equation: experience. This is done by giving positive/negative reinforcements to a response, to increase/decrease its occurrence.

However, Edward Tolman's experiments with rats and mazes indicated that our reflexes were not just a reaction, but the result of a thought process. When Tolman would close certain paths of a maze, the rats did not try that path because they knew it was closed, despite having no way to see that it was in that state.

As a response to the disregard of the mental processes by behaviourists, the so called black box [Ski74], **cognitivism** was born. Here, the learner is viewed like an information processor (like a computer), having short-term and long-term memories. In these memories, we have representations that are called when needed [WF86].

> "Cognitive theorists recognize that much learning involves associations established through contiguity and repetition. They also acknowledge the importance of reinforcement, although they stress its role in providing feedback about the correctness of responses over its role as a motivator. However, even while accepting such behavioristic concepts, cognitive theorists view learning as involving the acquisition or reorganization of the cognitive structures through which humans process and store information." [GE90].

In other words, one has knowledge structures, representations, that influence their responses to stimulus. This theory is responsible for the **Three-Stage Information Processing Model**, that says that an input first enters a sensory register, then processed in the short-term memory and finally transferred to the long-term memory, where it is available for retrieval [Bro58].

2.1.2 Learner-centered: constructivism and constructionism

Jean Piaget's theory of constructivism is arguably one of the biggest breakthroughs in the area of cognitive development. The foundations of this theory state that one forms his vision of the world **constructing** knowledge as he goes through his personal experiences, instead of absorbing knowledge that is communicated to him. This knowledge is built on top of pre-existing notions, changing the information as new data arrives [Str92], constructing knowledge structures.

Based on Juan Pablo Hourcade's work, a description of the three most important aspects of Piaget's work [Hou07] follows. The first aspect, already mentioned as one of the foundations of this theory, is the belief that one actively constructs knowledge structures from one's experiences and interactions with the world. Piaget called this process **adaptation**. The second aspect is related to the **factors that affect development**. Piaget stated that there were four factors that affected development: maturation, experience, social aspects and emotions [PI69].

- the children's maturation stage, be it cognitive or motor, is determinant to their ability to learn. Howerver, it is important to know that it does not determine how much a child knows;
- experience is the fundamental factor of the adaptation aspect, being required to build knowledge structures;
- the third factor is social aspects/interaction. This factor is the foundation of other theories, such as Social Constructivism by Lev Vygotsky, and it relates to everything that children learn from their social interactions (for example, knowledge passed generation to generation);
- finally, emotion, especially motivation, plays an important role because "children's motivations to learn are in great part due to their drive to grow, love and be loved, and assert themselves" [PI69].

The third and final aspect is the concept of **Developmental Stages**. Piaget stated that all children go through a series of stages sequentially, where each stage has a set of behaviours related to it. The stages defined by Piaget are: the sensory-motor stage (0-2 year olds), the preoperational stage (2-7 year olds), the concrete operations stage (7-11 year olds) and the formal operations stage (11-16 year olds).

However, Seymour Papert, one of Piaget's protégés built upon the theory of constructivism. Papert states that learning occurs better when we are "consciously engaged in constructing a public entity" [PH91]. Papert calls this theory **constructionism**.
There are two main takeaways of Papert's theory:

- first, children must be consciously engaged by what they are learning. This brings an emotional aspect to learning, where the child must be, first and foremost, interested in what he is learning;

- finally, by constructing a public entity, the artifact causes conversation that in its turn creates knowledge structures.

But Seymour Papert's work was not just on a conceptual level. His conclusions were validated with his field work with children, notably teaching children how to program. He believed that by teaching children how to master the computer, that could change how they learnt everything else [Pap93]. This belief came from the conclusion that children could not grasp some concepts because they were not concrete, due to the lack of contact with it in their day-to-day [Pap93]. By providing a tool of exploration to the children, the possibility of interacting with those concepts helps the child to understand the once abstract concept.

To support the learning of unfamiliar concepts, Papert suggested the creation of **microworlds**.

Microworld

A microworld, defined by Paper as an incubator for knowledge [Pap93], is an environment defined by the rules and constraints of a certain domain that allows children to explore that domain and understand the concepts behind it, building the knowledge structures associated to it.

The best example of a microworld is the one Papert defined in the foreword of his book Mindstorms, where he talked about the importance of gears in his learning [Pap93]. From an early age, he was fascinated by automobiles, knowing every part of some of its mechanisms. A few years later, he understood gears, and he started playing with them on his own. By understanding the underlying concepts of gears, differential gears, he could imagine them working on his head. Later, when he was at school learning mathematics, he could easily solve any problem and he even states that learning how gears worked, he learned more than throughout his whole elementary school. This kind of knowledge was acquired just by pure fascination about something and, by spending his pastimes playing with automobiles and its components, he learned a lot of concepts that: i) made sense to him because they were tangible (as in, he could see them work); and ii) made him understand intangible concepts (in the mind of the student) that were being taught in school, like multiplication and equations [Pap93].

2.1.3 Group-centered: social constructivism

Building on Piaget's work, there was a Soviet psychologist named Lev Vygotsky that believed that learning is affected if an activity is done in a social context or not. Later, this line of thought was called **social constructivism** [Vyg78].

One of his best known concepts is the **Zone of Proximal Development** (ZPD). There are things that children can do alone, and things that children cannot do at all, however there is an intermediate stage, in which children can do something if they get support. In Vygotsky's own terms, ZPD is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" [Vyg78]. The conclusion that one can take from Vygotsky's work in ZPD is that when children do not know how to execute a task and are accompanied by more capable peers they learn how to do it by watching others, allowing them to do that task by themselves the next time.

2.1.4 Summary

Piaget, Papert and Vygotsky's work is the main source of inspiration for this dissertation. As stated in the Motivation section, by empowering children with the right tools, they can build knowledge by themselves and with others. The concepts of constructivism, constructionism, microworld and social-constructivism form the foundations of this dissertation's work, since they encourage the creation of a platform that engages children in a collaborative learning activity. The application of these concepts in the proposed solution will be explained in the fifth chapter of this document: Research problem and methodology.

2.2 Collaborative learning through technology

One of the goals of this dissertation is to study how children can collaborate with each other, not only to engage them in a social activity, but to create a social layer on top of a learning platform that allows them to build knowledge collaboratively.

Before carrying on, it is important to define what collaboration is. Although the common definition of collaboration involves two or more individuals doing something together, researchers from several areas have different definitions [Lip02]. That said, when referring to collaboration, Roschelle and Teasley's definition will be considered:

> Collaboration is a process by which individuals negotiate and share meanings relevant to the problem-solving task at hand (...). Collaboration is a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem [RT95].

In the early 1990's, a new field of study emerged. Due to the work of several authors, some of which was referred in the previous section, education started to shift from the traditional teacher-centered way of instructing to a more cooperative approach. However, an interesting question was being posed by several researchers: how can these new instruction approaches be supported and enhanced by technology [Kos94]?

Meanwhile, researchers were investigating "the practices and shared artifacts by which groups coordinate their work" [Kos94], resulting on the creation of a new field of study called Computer Support for Cooperative Work.

To answer the question, a new field of study that focused on studying how collaborative technology could enhance instruction arose. This field is called **Computer Supported Collaborative Learning**, and it is the subject of study in this section.

Computer supported collaborative learning

In a nutshell, CSCL is about studying how people can learn together with the help of computers [SK06]. One of the advantages of learning in group is evident. As Koschmann states, "(...) learning in group provides opportunities for exposure to multiple perspectives and interpretations" [Kos94]. These perspectives and interpretations were not possible if not in a group environment, due to the unique combination of previous experiences of each participant. Following Vygotsky's theory of Social Constructivism, where social context is an important variable on the learning process, CSCL shows technology's importance in that same process.

One of the most common scenarios of the application of CSCL's theory in a real environment is the introduction of text based messaging, best known as chat. Most of the learning in this scenario occurs in the arguments that happen on the usage of this particular technology. If we imagine a real-world collaboration, even if it is mediated by technology (for example, a group of individuals around a computer), most of the learning also comes from the discussion between those individuals. This happens due to the "shock of our thought coming into contact with others" [Pia28].

However, this shock can also occur in other scenarios, where discussion is not necessarily happening. When executing a task collaboratively, just by observing the other person doing it, it can also provoke that shock, creating a unique learning moment, just like Vygotsky concluded in the aforementioned theory of Zone of Proximal Development.

This piece of the puzzle is absolutely fundamental to the success of this project. The debate between colleagues can contribute to their understanding of the concepts, as well as immerse them deeper in the activity. This way, collaboration will contribute not only to the building of the knowledge structures, but to adding an extra dimension to the engagement of the child with the platform.

2.3 Creating an engaging experience

One of the most difficult challenges of this project is the fact that, for learning to occur, one must engage children in the activity they are performing. As mentioned, one of the goals is to motivate students to explore on their own. This means that this dissertation's result is a launch ramp to the area of music composition, in a way that it introduces musical concepts that, on one hand, motivates the student to pursue further education, and on the other that it might prove useful later when the student wants to learn more complex concepts (for example, from formal education).

According to the Oxford Advanced Learner's Dictionary, engagement is defined as "being involved with somebody/something in an attempt to understand them/it" [Pre11]. This definition exposes two different perspectives, one explicit and the other implicit, that are extremely relevant to this dissertation: i) being involved with something in an attempt to understand it; ii) being involved with something, **with someone** in an attempt to understand it.

These perspectives define what needs to be taken into account to build a platform that engages children in an unique experience.

2.3.1 Being involved with something in an attempt to understand it

Following Papert's example in Microworld, he stated that he was completely engaged in automobiles and their inner workings. This engagement resulted in him learning complex concepts **by himself**, concepts which he used throughout his life. In fact, as mentioned earlier, this is one of the foundations of constructionism and a major difference in relation to constructivism: the fact that learning occurs best when the participant is actively engaged when building in knowledge. However, Papert also added another dimension that is a fundamental contribution to this vision: the participant is actively engaged in constructing a **public** entity.

To be engaged in an activity, one must be attracted, surprised and provoked by what one uses [Car04]. When things surpass our expectations, challenge us, they arouse emotions, which in turn create a response. The task here is to understand how the design of this platform can create an engaging experience by evoking emotions.

2.3.2 Being involved with something with someone in an attempt to understand it

Finally, this facet of the platform is also very important to engage children. As stated in sections 2.1.3 and 2.2, engaging in collaborative activities helps on building knowledge structures [Vyg78] [Kos94] [Pia28]. The child might learn from someone more experienced, as well as generating new ideas from discussion. Besides, composing, for example, a song, can be complex and time-consuming for only one person. If we could distribute roles throughout the students of a class, each one would create a bit of the final piece, or they could collaborate in small groups to create pieces of the final result. By working together, they can achieve a richer result.

2.3.3 Summary

This section presented the two major problems in this topic, in relation to this dissertation.

There is one problem, however: how can one even measure if children are engaged in this platform or learning at all? This might prove as a difficult point in this project, and it is going to be explored throughout this document and further discussed in the last chapter, 10 Conclusions.

2.4 Exploring music

First and foremost, what is music? As simple as it may seem, there is no universal definition of music. One of the most used definitions is Edgard Varèse's, that says music as being "organized

sound" [Gol61]. However, what (or who) determines if the sounds are organized or not? We can see a cultural aspect emerging here, because someone might perceive something as music, while others do not. If something is not music, what is it? Jean-Jacques Nattiez stated that "(...) just as music is whatever people choose to recognize as such, noise is whatever is recognized as disturbing, unpleasant, or both" [Nat87]. Here, the cultural aspect is evident, where difference between music and noise is in the listeners mind, not in a strict set of predefined rules.
Although children who do not have any knowledge in music can create it with form and structure [NF05], is it really necessary to perceive it as such? In other words, what is more important: to let the child explore, or to teach him how to compose something that is perceived as music?

With this in mind, when referring to the activity that will take place when children are interacting with the platform, is it correct to call it musical composition? The common-sense version of musical composition says that it is the creative act of conceiving and organizing the parts that make up the music as a whole [Alp84]. However, to compose a piece of the music, the composer has to imagine how it will sound like. To create the actual piece, the composer can try it out on an instrument to hear exactly what it sounds like, or he can imagine it in his mind [Alp84]. Regardless of the approach, the composing act comes from the composer's mind, and this is what this work is focused. When children are exploring, tinkering with the bits and pieces of a song, they are actually composing it.

Taking on constructivist theories, we can immediately establish a relation between this exploratory activities and the construction of the child's knowledge. This connection is important to define how this platform might help children understand the basic concepts of music theory. However, these concepts will not be explicitly taugth. Later, if the child takes a more formal path, he will be able to recognize that he already mastered these concepts, from the knowledge he built from a hands-on experience.

2.5 Understanding the relation between children and computers

Having discussed the theories of cognitive development, to understand how children learn, how a collaborative environment can help in the learning process and how we can engage children in this activity, there is still one piece of the puzzle missing.

Technology-Mediated Environments provide great opportunities for contructivist learning, based on the resources they offer [OH96]. However, technology being the medium, we must understand the relation between children and that technology.

This chapter is going to explore how that brings it all together. Here, it will be discussed how one can actually operationalize all these theories into something tangible.

When researching children, in order to know more about them and their needs, and as mentioned earlier, one cannot rely solely on his own experience nor in teachers and parents [Dru02]. In this project, we are going to have to understand how we can improve the learning process with technology. Therefore, so one can learn more about children and their needs, we must ask them directly and learn from their experiences [Dru02].

This chapter discusses how can we learn more about children and how can we approach this problem, in order to create a custom tailored experience that meets the goals defined in this project.

2.5.1 Human-computer interaction

> "The actual dawn of user interface design first happened when computer designers finally noticed, not just that end-users had functioning minds, but that a better understanding of how these minds worked, would completely shift the paradigm of interaction" [Kay90].

Any product that we use has a way we can interact with it. Just by looking at all the products around us, we can easily identify some of the possible interactions with them. My wristwatch informs me of the time and it possesses an input to allow me to change the position of the handles. My computer mouse, when connected to a computer, allows me to interact with it by moving a pointer on the screen. All these objects may convey information and/or allow manipulation. Therefore, we could define interaction as a process of information transfer [Dix02].

In the 1980's, a discipline with the aim of studying how we can design more usable computer systems [Har08] was born - that discipline is Human-Computer Interaction (HCI). As computer systems grew in complexity, so did the interactions associated with the actions we could perform with them. At the time, for computing to continue its growth, we needed to understand users and the ways we could empower them in the control of these systems [Car11].

To provide a clear vision of HCI, in order to contextualize it in this document, we must define it. There are many definitions of HCI. The Special Group of Computer Human Interaction (SIGCHI), a part of the Association for Computing Machinery (ACM), defines HCI as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" [HV92]. Harper et al, define it as "a term used to refer to the understanding and designing of different relationships between people and computers" [Har08]. Independently of the definition, we can see HCI as a cornerstone of the design process of computing technology, studying how people interact with systems, and how that interaction can be improved. In the beginning, HCI focused on the 'fit' between the user and the system [Har08], studying how that interaction could be optimized. HCI has been, from the beginning, a multi-disciplinary area, resulting from the convergence of several disciplines, such as cognitive engineering, an evolution of cognitive science, and human factors engineering [Car11].

As HCI evolved, the focus started shifting from the users physical characteristics to the mental characteristics [Har08]. There were several important changes in HCI in the last thirty years. Among these changes there were two extremely relevant to the context of this dissertation. First, **collaboration** has become a central aspect to the discipline, fostered by the increasing importance of groups of people working together through interconnected computer systems [Car11]. However, one of the most interesting changes happened in the last decade, and it is the era of HCI we are currently at - the User Experience (UX) era. The introduction of UX brought, between others, an **emotional** aspect to this discipline. This can be proven by the common use of the words "fun", "engagement" and "desirable" in recent literature ([Car04]; [RM06a]; [SMR06]).

However, even with the great evolution of HCI as a discipline and as a science, its tools and methods are tailored mostly to mainstream adult users. Having in mind that the target audience of this dissertation is children aged four to twelve years old, a lot of the techniques that are typically used in this discipline may not apply. To work with the unique characteristics of children, **Child-Computer Interaction** was born.

2.5.2 Child-computer interaction

The literature referring to the work with children when creating new products has been growing in the last fifteen years. As Read puts it, there are three core differences between children and adults, or as she calls it, the ABC of Child-Computer Interaction [Rea05]. Starting with **Activities**, Read states that children's use of the computer is very different from the one of adults, where children are more likely to be playing than working. Also, they are not task-driven, which invalidates a number of concepts and tools from Human-Computer Interaction. **Behaviours** is the second difference stated by Read between children and adults, where, inside the same application or tool, the younger use it in a very different way, like for example searching random words in Google. This difference in behaviour comes from the incompleteness of children's knowledge structures (for example, spelling) and their desire to do fun things. Finally, we have **Concerns**. Here, Read states that when we are evaluating software for adults, we generally focus on factors like usability, learnability and user experience. Besides, we have the experience of being adults ourselves, so it is easier to put ourselves in that perspective. However, with children the concerns are quite different. For example, one has to be aware of content restrictions on the Internet, thus being concerned with their safety. Another factor that might create problems to the designer is that children want fun products, products they want to play with, where most designers want to create educational products.

Now that the foundations of these areas are laid, we have to refer to the original question posed in the introduction of this document: how can we create a platform that engages children in a collaborative learning activity? To answer this question, the concept of designing a product using children as part of the design team will be explored. That takes me to the next chapter: Designing for children, with children.

Chapter 3

Designing for children, with children

The previous chapter left two topics of discussion open: i) how can we create a product that engages children in a collaborative activity that helps them understand complex concepts and ii) what is their value in participating in its design process.

This chapter is divided into three sections. The first section investigates those topics further. The second section presents several design methodologies created specifically for children, that will allows me to operationalize this platform into something tangible. The third, and final, section presents an overview of these methodologies that will allow the selection of the methodology to be used.

3.1 Children in the design process

In the 1990's HCI two main approaches to the design process were introduced: User-Centered Design and Participatory Design.

User-Centered Design (UCD) was introduced in 1986 through the hands of Norman and Draper, and its goal was to put the users in the center of the design process, taking into account its needs and interests [ND86]. In this approach, the users are positioned as testers or evaluators, to ensure that their needs and interests are met. This approach, although its popularity, has some pitfalls. The first is that users take a reactive role in the process, reacting to the design made by the design team [SRAD97]. Another pitfall is that, by introducing users so late in the design process, the organization might not be able to react to the results of user testing, due to budget, time or any other kind of limitation [SRAD97].

Almost at the same time, a new approach called Cooperative Design was rising in Scandinavian countries [BEK87]. The main difference to UCD is the degree of involvement users have in the design process. According to Muller, "the goal is to provide an equal opportunity design environment in which all participants can contribute as peer co-designers" [MWW93], meaning that the user is not just in a reactive position, but actually a part of the design team from the start, contributing to the actual creation of the design. As the approach evolved, it became better known as Participatory Design [SN93].

However, there is one limitation with Participatory Design (PD), and similar methodologies: they are most effective with adults [SRAD97], meaning that in order to use this kind of approach with children, we must adapt them [Dru99].

In the 1990's, researchers started including children in different stages of the design process, from using children as informants in the beginning of the process [SRAD97], to using children as design partners [Dru98b], similar to the likes of the Scandinavian approach.

Inducing such degree of involvement is extremely important, as children are very good on telling us their needs and interests, making the task of understanding what engages them easier [SRAD97]. A lot of research has been made in this direction, notably Allison Druin's work with children, demonstrating their value as design partners [Dru94] [Dru98a] [Dru02] [GDC+04] [TDFK01]. According to Druin, there are four different roles that children can play in the design process of new technology: **user**, **tester**, **informant** and **design partner** [Dru02].

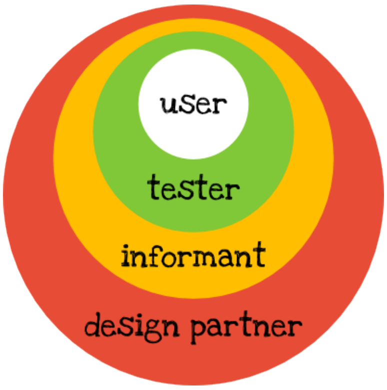


Figure 3.1: Roles of children in the design proccess [Dru02]

Children as users

In a nutshell, when children play the users' role, the goal is to observe them using a given piece of technology so that the impact of existing technologies can be understood, in order to create new technologies that change or define the future of the context they are in. In this degree of involvement, the relationship between children and the research team is **indirect**, where there is no interaction, just observation. Also, the users are brought in a very late stage or, in other words, when the product is developed [Dru02].

Children as testers

In the testers' role, children are also observed using technologies. However, these technologies are still in the making, being in a development stage, unlike the finished product when children had a role of users. The goal of this role is to obtain feedback on the product, so that the team can improve it before it comes out to public. Here, children are **observed** using the product (or a prototype) and they are **asked feedback** about it. So, they are only brought to the design process after the initial design is completed [Dru02].

Children as informants

When children play the role of informants, they can be a part of the process before any technology is finished and during its development. We can think of it as a mix of the roles explained above, where children can: i) inform the research team before anything is developed, giving insight about their experiences in the domain or using available technologies, and ii) can give feedback on the various iterations of the product development process. So, in this role children **inform** the research team at any stage of the process, even before anything is actually designed, they are **observed** using existing technologies or the technology being developed, and they give **feedback** throughout the development or the final product itself [Dru02].

Children as design partners

Finally, the role of children as design partners is similar to that of an informant but, in this role, they are part of the design team, collaborating to the design of the new technology. In this role, children are considered **equal stakeholders** in the design process due to their unique perspective, different from researchers and others partners contributing to the design process. So, in this role, besides every role that children played in the previous roles, they are also part of the design team as **equals**, contributing to the development of new technology not only with feedback or insight, but also with their expertise and their unique vision [Dru02].

Although working closely with children has its drawbacks [Web96], the questions raised in this dissertation require a good understanding of children's unique perspective, giving insights on how to create an engaging experience.

3.2 Design methodologies to work with children

As the previous section states, the number of methodologies to design products with children has been increasing. This section gives an overview of the methodologies and frameworks I have considered most relevant to the context of my work, in order to define which one (or combinations of) will be used in the design of this platform.

The selection of these methodologies and frameworks was based on three factors: i) the degree of involvement of children with the design team; ii) the target age of the product being developed, and; 3) the relevance in the literature (number of citations).

3.2.1 Cooperative Inquiry

Allison Druin proposes a research approach for the development of new technologies with children as design partners, based on techniques from Participatory Design and other approaches [Dru99]. However, Druin clearly states that the methods that form this methodology are not a magic formula to work with kids. They should be interpreted as a philosophy or an approach that can be used to collect data, prototype and create new research directions.

This approach to partnering with children consists on three basic techniques:

Contextual Inquiry

Contextual Inquiry is a methodology that states that researchers should collect data in the users own environment [BH98]. In Cooperative Inquiry this methodology has been adapted because children are part of the design team, so they also have the task to observe other children, that are not involved in the design process, alongside the adults in the team.

One problem Druin's team had was that children and adults were not comfortable in the way both took notes. While adults preferred to write theirs, children combined drawings with text, creating cartoon like flow charts. In order for things to work, each one took notes as they were most comfortable with.

One of the most important points Druin makes here, is that, when interacting with children, the person interacting does not take notes, leaving that responsibility to, at least, two members of the team. This happened because, when the interactor took notes, children would get distracted or they would feel like they were being tested. Also, the hierarchy between the adults and children can be difficult to overcome, because the child may look at the interactor with the same authority as of a teacher or a parent.

Finally, when children were observing and interacting with their colleagues, they would sometimes distract themselves and join the activity they were observing, forgetting they were there to research.

Participatory Design

The second technique presented by Druin was adapted from Participatory Design, already explained in this document, where both adults and children prototype together the technology being designed. The most important point that Druin makes is that adults must view children as their design partners, and that both should make design decisions. In this prototyping sessions, all the design team must contribute to the solution equally. The adult should not lead the session; he should step back and let children do all the decisions.

Doing this session based on the observations from contextual inquiry works best because it generates discussion and it can bridge collaborative brainstorming activities.

Technology Immersion

The third and final technique is Technology Immersion. This technique consists in observing children using large amounts of technology over a concentrated period of time. The purpose of this technique is that, combined with context inquiry and low-tech prototyping, it can highlight patterns and roles that were not obvious on the context inquiry sessions.

3.2.2 Mixing Ideas

This methodology is an adaptation of Cooperative Inquiry to younger aged children (ages four to six). In a sentence, **Mixing Ideas** is a framework for merging individual ideas into bigger, collaborative ideas. This technique was developed during a research project named "Classroom of the Future", that had the goals of: i) understanding the needs of young children (ages three to six) in learning environments; i) developing new technologies in partnership with children and teachers; and iii) understanding the impact of these technologies can have in younger children and their early childhood environments. The team met twice a week for one hour long sessions for the duration of one month [GDC^{+}04].

Although the age range of this methodology is not the same as this platform, the techniques used are relevant to this dissertation's work.

This approach is divided into three different stages.

First stage: each individual child generates ideas

At the first stage, each individual child, accompanied with an adult, observes its colleagues doing a specific task while they are on a recreational moment, recording what they observed through drawings. After that, children are prompted to improve what they drew or what they saw other children doing, explaining them that sometimes the best way to generate new ideas, or to improve something, we must observe other people look at old ideas.

At this stage, the only responsibility adults had was to record what the observers were saying, as well as encouraging them to have lots of ideas.

Second stage: initial mixing of ideas

At this stage, groups of two to three children are formed, so that each group generates an idea by mixing the individual ideas generated in the previous stage. They start by drawing every idea in a table-sized paper. At the beginning of the session each individual child presents their ideas to the rest of the group, not only to share it with others, but also to remember them. The ideas are then placed in a large mixing bowl and stirred, to see what comes out. For children to understand the concept of stirring ideas, the adult team gives the analogy of baking cakes: where the ingredients on their own are not very good, but combined they make something delicious. After stirring them, everyone discusses how they can mix it to generate a better idea, that is carried to the third and final stage.

Third stage: mixing the big idea

The goal of the final stage is to mix all the ideas generated by the groups into a single, big idea. To do this, following what was done at the second stage, each idea generated in the previous stages has to be presented to everyone. However, instead of drawing all ideas into a single piece of paper, the previously drawn ideas are cut into small pieces. Armed with tape, the children are able to rearrange them physically to create new possibilities. In the end, the final idea is drawed onto a large piece of paper.

3.2.3 (Modified) Layered Elaboration

This methodology, created by Walsh et al, is based on this basic concept: ideas are successively added to the design in a layered fashion, building on top of earlier ideas. This is possible by drawing on a transparent material (acetate sheets, for example) and piling them up so that every idea is always visible [WDG+10]. Layered Elaboration allows for new designers to work on existing ideas, never destroying the original ones.

The process starts with an initial idea on a storyboard, created by an adult designer. The storyboard is placed on top of a hard cardboard rectangle, topped with an acetate sheet ready for drawing. In small groups (one adult and two to three child design partners), the designers would draw their ideas using only one color, one at a time, while narrating what they were doing.

When the group decides that the storyboard is complete, the sheet is removed and replaced by a new one for the next group. When all groups finished the storyboard, all of the sheets are stacked on top of the original storyboards, so that the researchers can identify patterns and hot-spots.

However, the researchers felt that this methodology could be improved: they felt there was some lack of communication between the team members, using only one color to draw ideas was limiting and the design partners did not feel like they owned the ideas. This said, the team decided to revise and modify the method.

The modified version of this technique emphasizes collaboration and elaboration between groups. To increase the ownership of the design partners, small teams of two children and at least one adult are formed, and each team is assigned to one problem, having fifteen minutes to do it. After those fifteen minutes, all of the groups get together in the middle of the room and do a stand-up meeting to debrief. The problems then rotate between the groups, and a new session of problem solving begins.

This process lasts until every team solves every problem. In the end, all of the teams sat down and discussed all of the designs, identifying the ideas and writing them on a white board.

One of the most interesting points the authors described is that children took this as a game and, later, asked the teacher to play the *prototype game*.

3.2.4 Informant Design

Informant Design consists of a child-centered framework positioned between User-Centered Design and Participatory Design. Here, children are neither users nor participants - called **native informants**. This means that their role consists in teaching the designers about the context of the project, which the designers are not aware. This decision was based on the assumption that children cannot have the necessary involvement to become design partners.

The team used in the execution of this framework is formed by two psychologists specialized in educational technology, a HCI specialist and a software/graphic designer.

This framework, developed for interactive learning environments, is divided in four phases:

Phase 1: define domain and problems

The goal of this phase is to specify appropriate learning goals and identifying the pros and cons of current teaching practices within the domain. Children are asked about the experience of being taught these concepts, to understand their depth. In parallel, the teachers are asked on how would they approach these concepts. Also, a teacher panel is formed to discuss the importance of computer-aided teaching materials.

Phase 2: translation of specification

The main concern at this phase is to relate the problems identified in the first phase to the possibilities afforded by the interactive system environment. Here, the team wants to bridge the gap between the abstract representation of the problem and the events that it represents. The result is a set of prototypes, or runnable prototype animations.

Phase 3: design low-tech materials and test

This phase consists in the evaluation of the aforementioned prototypes with children to validate and improve the designs. Paper prototypes are built and taken to schools in order to validate the assumptions of the team:

- **Design Assumptions:** do the children recognize the elements of the environment?
- **Cognitive Assumptions:** is the design giving aid to the learning of the concepts?

To validate these assumptions, three exercises are done:

- **Validity of design and cognitive assumptions:** the elements are shown to the children and, asking questions, the team seeks the manipulability of the elements and their contribute to the overall goal: solving problems;
- **Familiarity with technology:** here, the team tries to find what children thinks of the technology they had contact both at school or at home.
- **Envisioning interactive software through interacting with the low-tech materials:** here, to get around the problem that originated this framework, the assumption that children cannot be design partners, the team asks children how would they design the software for others one or two years younger than themselves.

Phase 4: design and test hi-tech materials

In the fourth and final phase, hi-tech prototypes are developed so that children could have a say in what they think is right or wrong with the program. Besides the children, teachers are also involved in this process. The result is that children point problems in the interface, while teachers are more concerned with the value it has in the classroom.

3.2.5 KidStory

This design methodology, which derives from the aforementioned Cooperative Inquiry, starts with educational sessions to evaluate existing technologies [TDFK01]. The main purpose is to provide children with a framework for thinking critically and to help children and adults become design partners. The result is then fed into brainstorming sessions, where ideas for new or existing technologies are generated. The ideas are then analysed and selected by the researcher(s), so that prototypes are created for further refinement by children.

The method is composed by three different types of sessions:

Sessions with educational activities

As mentioned before, the main purpose of this session is to help children and adults become design partners and to provide the children with a framework for thinking critically. A number of sessions on how to be an inventor are organized, so that children understand their role on the project.

Evaluation sessions

These sessions are organized to obtain information about new technologies. The goal is to encourage children to use the skills obtained on the educational sessions to identify problems with existing technologies. This kind of session is particularly powerful when suggestions made by children and adults are implemented and brought back to school, since it can give children a feeling of empowerment and ownership of technology.

Brainstorming sessions

The goal of these sessions is to generate new ideas or elaborate on existing ones. To express those ideas, low-tech prototyping is used. The whole team discusses the project at hand and then splits up in smaller teams, to start generating ideas. At the end, everyone gathers up and explains the ideas they came up with.

3.2.6 Bluebells

This design methodology is placed between child-centered design and expert design, used with children aged between seven and nine years old, and it is divided in three stages: before play, during play and after play [KMH06].

Before play

In this stage the design team identifies requirements in relation to the constraints of the project. This stage is solely carried out by adults, resulting in a list of requirements, a technology specification and a notion on how the end product will look list.

During play

In this stage four activities with children are carried out: i) I-Spy; ii) Hide and Seek; iii) Tig, and iv) Blind Man's Bluff.

I-Spy is used to gather context information, where the designers observe children in the environment of the application.

Hide and Seek is used to gather information about the content for the application of the product. Hide and Seek is divided into two parts and it requires a prototype. At the first part, children produce a list of words they might associate with the application. At the second part, children are given a prototype with blank spaces so that they fill it with content. This technique is used for designers to get insights about children's perceptions of the context, their knowledge, their preferences, the topics they are familiar with and the topics that are relevant to them.

Tig is used to gather information about navigation and control. Children are given screens and artifacts, and they must place the artifacts in the screens, so that designers understand how children see the navigation and interaction on the interface. Blind Man's Bluff is used to get the feel of the interface, where the children, in pairs, draw what they think it should look like.

After play

The team examines the outputs and incorporates them in the design documentation as well as using them to produce initial prototypes.

3.2.7 CARSS - Context, Activities, Roles, Stakeholders and Skills

CARSS is a framework for Learner-Centered Participatory Design (LCD) involving children [GR06]. LCD is an approach proposed by Soloway et al that puts learners at the center of the design, addressing their special needs, based on four foundations: i) understanding is the goal; ii) motivation is the basis; iii) diversity is the norm; iv) growth is the challenge [SSJ+96].

The authors define framework the same way Rogers and Muller do, who suggest that "within HCI, it is commonly used to describe a form of guidance that is explicated in a particular way to inform design and analysis" [RM06b], meaning that this should not be used as a recipe, but as a way to raise awareness to a certain number of parameters.

Having this in mind, they define CARSS as a framework composed by five components: Context, Activities, Roles, Stakeholders and Skills.

Context

Context is used to raise awareness on the constraints of where the design activity takes place. The authors identify the following constraints:

- Curriculum constraints, referring to the change of the curriculum between regions;
- Timetable constraints, due to the difficulty of arranging design sessions with the students schedule, and also the school schedule (having in account holidays);
- Environmental constraints, because of the importance of having a good place to do the design sessions;
- Commercial constraints, when the project being developed involves an industrial partner it must consider time/money restrictions;
- And finally, legal and ethical constraints, that consider the approvals needed to work with children, as well as their rights and issues in child protection.

These constraints exist and must be considered by the designers, as they shape the direction of the project.

Roles

This component describes all the roles the member of the design team can fulfill. The importance of these roles depend on the project at hand. The roles identified by the authors are:

- Design partners, a role only fulfilled by children, where they have to do design tasks from gathering requirements to evaluating;
- Project manager, the person who makes sure that the project is going to meet its schedule;

- Technology specialists, who must be the ones who make sure of the technical feasibility of the project, as well as implementing the high-tech prototypes;
- Researchers that provide the theoretical knowledge needed for the project to complete its goals;
- Subject matter experts, that provides the knowledge to the subject at hand;
- Child development experts, who defines how the subject will be presented to children;
- Learning scientists, that contribute with their knowledge to improve the learning process;
- Collaboration facilitator, that facilitates the relationship between the children and the members involved in the project.

Stakeholders

Although some methodologies focus on a small group of stakeholders, this framework states the importance of defining every stakeholder to ensure the success of the project. The authors have identified the following stakeholders:

- Children, the major stakeholders of the platform, due to their importance in the design process;
- Teachers, that give expertise on the context of the project, such as the curriculum, their opinion on if that technology is going to work, that children may not possess;
- Parents, a stakeholder that is often ignored in other models, must be taken in consideration especially in technology that is going to be used in a home environment;
- Industrial Partners, a stakeholder that must be considered in commercial projects;
- Academic funders, that determine the nature of the project itself, as well as if the project fulfills the criteria needed for it to be funded in the first place. enditemize

Activities

This component defines the activities that are going to take place throughout the design process, and defines the involvement of the stakeholders and which roles they can play. Briefly, the authors identified the following activities: requirements gathering, design, evaluation of prototypes.

Skills

The final component consists of the skills that every member of the team must have and, if they do not have it, the willingness for aquiring them. The core skills members must have are: i) sythesising skills to see problems in a new way and propose new solutions; ii) the analytic skill to recognise potentially successful ideas, and 3) the practical contextual skill which enables the originator of an idea to convince others of its merit. The authors refer the skill-set children and adults must have seperately.

3.3 Summary

Now that a description of the most relevant methodologies in the literature was made, an overview of their characteristics and how they can relate to this particular project is going to be presented. These characteristics were chosen based on their common points and their relevance to this dissertation's work. The **Age** parameter refers to the age of the children in the design team, not of the target audience. The **Role** parameter is based on the four roles Druin defined, as stated in Children in the design process - user, tester, informant and design partner. Next, although that information was not available in all the methodologies, it is important to determine the **Size of the design team**, as the execution of the methods depends on that. Finally, the methodologies by the **Activities** that were performed were categorized. These activities can be: analysis, idea generation, prototyping and evaluation.

To present a friendlier overview, this information is represented in a table:

Methodology / Activity	Age	Role	Size of Design Team	Activities
Cooperative Inquiry	7-11	Design Partners	Six: two investigators, two students and two staff	Analysis, Design, Evaluation
Mixing Ideas	4-6	Design Partners	-	Analysis, Idea generation
Layered Elaboration	7-11	Design Partners	One adult for two children ratio	Prototyping
Informant Design	7-11	Informants	-	Analysis, Idea generation
KidStory	5-7	Design Partners	Two-three adults for three-six children	Analysis, Idea generation
Bluebells	7-9	Informants	-	Analysis, Idea generation, prototyping

Table 3.1: Overview of the methodologies described in 3.2

As you can see, there are major differences in the approaches these methodologies follow, especially in the involvement of children in the design process. Parsing these methodologies made me see not only their differences, but also their similarities.

One of the factors that pops out is the size of the teams that Cooperative Inquiry, Layered Elaboration and Bluebells require. A very important aspect, that is going to be addressed again in the Design methodology section, is that I am a team of one - although children are part of the design team, there is only one person to do the rest of the tasks. Although what the authors propose can't be used directly, the methods can be adapted.

There are also differences in the role children have in these methodologies. Children are included as design partners in four of the methodologies, and as informants in the remaining two. Of the reasons for including children as informants is that the authors belive children are not capable of designing feasible concepts. Although this might be a problem, the other four managed to produce interesting results based on the children's design.

Finally, the age factor. The platform being designed is for children aged between four and twelve. It is necessary to find a group of children whose age allows them to participate without any restrictions (due to, for example, being underdeveloped socially or cognitivelly) and that represent the target age group.

There is still one thing to do before proposing a solution to this dissertation's problem: how others have addressed this problem before has to be investigated. This takes us to the next chapter: Music tools for children.

Chapter 4

Music tools for children

This chapter will describe some projects that are somehow related to the goal of this dissertation. It is important to see the approaches other people used to solve similar problems, and their end results. The work is divided in two categories: **non-collaborative** and **collaborative** music-related tools. This parameter was used since collaboration is one of the most important aspects of this dissertation.

4.1 Non-collaborative music-related tools

This section will describe seven non-collaborative music-related tools whose concepts or features were found related and relevant for this dissertation.

4.1.1 Hyperscore

Hyperscore is based on the idea that musical notation is just a way for people to remember what they have played before, and that the system that we use today is what creates a gap between people and music.

Hyperscore is a software built for Microsoft Windows® that allows people to compose music through its own special notation system: drawings [Lin11]. The software offers a set of tools that allow you to draw lines, change their color and length, and the software just translates those drawings to music. Although the paradigm is so simple, it is possible to create complex pieces.

This piece of software is well executed. The concept itself is really interesting, presenting the kids with an intuitive and engaging way of composing music. However, it has its pitfalls, such as the lack of collaborative features.

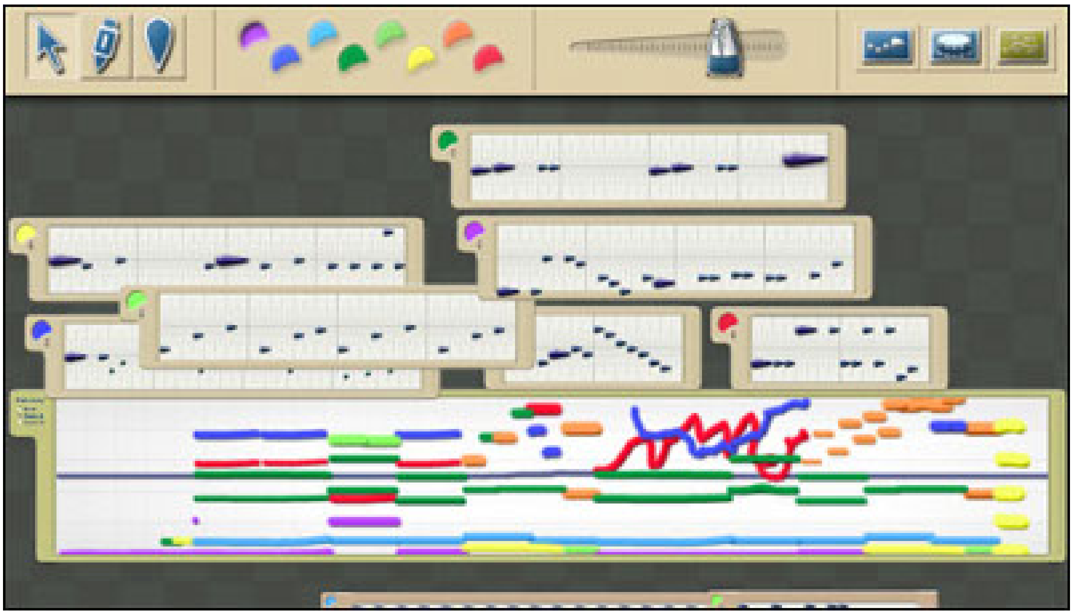


Figure 4.1: An example of Hyperscore's canvas [Lin11]

4.1.2 Groovy City

Figure 4.2: Groovy City's creation mode [Sib11]

This software, only available to Microsoft Windows®, is targeting at children aged between 9 and 11 years old, and its goal is to teach children about music and music creation [Sib11]. The software is divided in two modes: exploration and creation. In the exploration mode, children can navigate through music lessons that explain the concepts of music theory and solve exercises. In the creation mode, children can create music in a futuristic environment. The child has an avatar that moves forward, and he has several elements, buildings, spaceships, where each element represents a different sound group (percussion, strings, *et cetera*). He then places those elements in a linear fashion (the avatar only moves forward) and, when he presses play, the avatar starts walking while sounds are producing as he passes through the placed elements.

4.1.3 San Francisco Kids

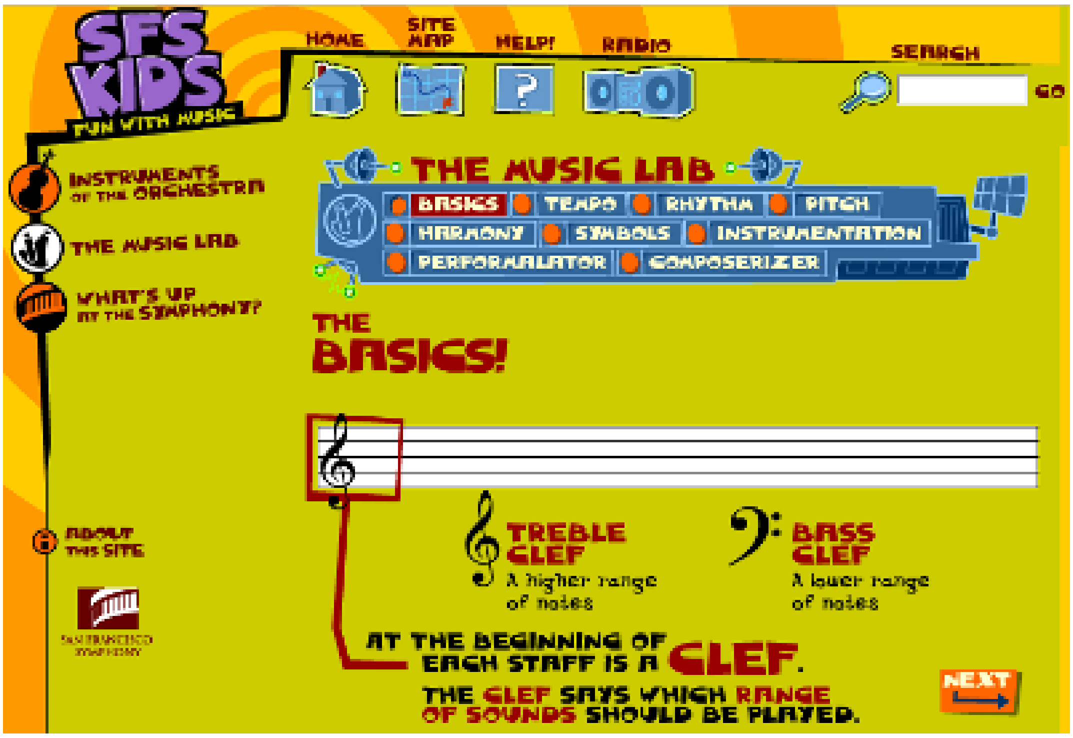


Figure 4.3: Learning with San Francisco Kids [Sym11]

At the San Francisco Kids website, built in Adobe Flash® by the San Francisco Symphony, children can go through a set of lessons that teach the fundamentals of music theory, like notation, tempo, rhythm, and others, in an easy and engaging way [Sym11]. The music lab, the zone of the website where children can learn music theory, also has two interesting tools: first, the *Performalator*, presents a small keyboard where each key has a different color, and the score of simple musics, where the notes have colors that tell what key must be pressed. Finally, the *Composerizer*, has a small set of pre-made melodies, and children can drag and drop them in a musical staff.

This website engages children through its visual design and catchy interactions. This website is clearly focused on the learning side, rather than composition side.

4.1.4 FlexiMusic Kids Composer

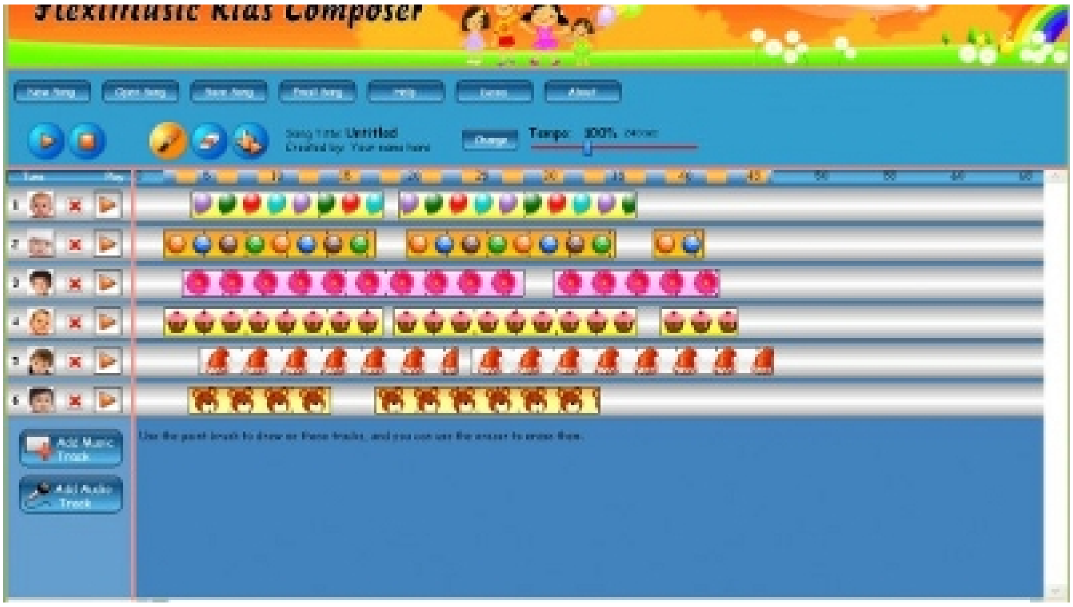


Figure 4.4: An example of FlexiMusic Kids Composer's canvas [Fle11]

FlexiMusic Kids Composer is a music composing software for kids available for Microsoft Windows ® [Fle11]. The concept behind it is teaching music by providing a hands-on experience. Similar to other tools already presented, here children can create music simply by painting. This is a very powerful tool, allowing the creation of complex music, only limited by the users' creativity. However, the user interface is quite confusing and the organization of all the functionalities is not clear nor intuitive.

One of the most interesting functionalities this tool has is that it allows sharing the created pieces with friends by e-mail. Although this is far from being collaborative, it shows a clear effort to introduce a social facet in the software and it contributes to learning, through discussion and critique.

4.1.5 Toons Tunes

Toons Tunes is a social network, built in Adobe Flash®, based around the concept of music, where children can experience music, create it and share it [Tun11]. By having social features at the core of its concept, this platform provides an engaging experience to children, while stimulating their interest for music. Here, children choose an avatar and explore a virtual 2-D world, where they can: i) interact with other avatars, through jamming features or just by talking to them, or; ii) create their own music, and share it later with other players. Although this platform is extremely

Figure 4.5: Toons Tunes' mix-o-matic [Tun11]

well built and is visually appealing, the music composer is below par. Here, children can only mix together a set of pre-made samples to create a song. Although this provides instant gratification, it does not have the exploratory features that engage children in longer and more intensive creative sessions.

All in all, it is a fantastic platform because it stimulates kids interest in music through an engaging and interactive social experience. Nonetheless, the music composer is limited and it does not allow collaborative creation.

4.1.6 Isle of Tune

Isle of Tune, built in Adobe Flash®, calls itself *"a music sequencer for the modern colloquial"* [oT11]. This project has some traces of constructionist concepts, explained in chapter 2, where users are presented with an empty island, where players have to make music by constructing elements like houses, roads and cars in it. Cars represent the band members, houses and other roadside elements represent the instruments (or the sounds they produce) and roads represent the logic in which sounds are played. We simply create a road, place houses or other roadside

Figure 4.6: An example of an Isle of Tune island [oT11]

elements, and insert a car on the road. When the car passes through the elements, they produce a sound.

By using objects children already know, such as islands, cars, roads, buildings, *et cetera*, things stop being arbitrary. Children make an immediate connection between the relation of each particular object with an action/effect. For example, a car rides through a road, and they understand how music can be done mixing these objects.

The complexity of the songs can be immense, as the platform has a top for the best songs created, and there are some interesting translations of famous songs.

Although being a very interesting project, specially because of the constructionist approach that is used, there are not collaborative features - these would greatly increase the potential of this tool.

4.1.7 DrumSteps

DrumSteps is a percussion composition micro-environment [JT01] based on construstivist microworld made of steps and ladders. To make sound, a ball is dropped on top of these steps and ladders - when the ball hits them, it produces a percussive sound. Each ball represents a different sound and the steps and ladders represent when these sounds are played.

This tool is based on one of the principles this dissertation is based upon: microworlds. Children are not interacting with instruments. They are placing steps and ladders in an empty canvas and dropping bouncing balls onto them, resulting in interesting and sometimes complex percussive rhythms.

Figure 4.7: An example of DrumSteps' canvas [JT01]

4.2 Collaborative music-related tools

This section will describe four collaborative music-related tools whose collaborative features were found relevant for this dissertation.

4.2.1 Team Composer

Team Composer is a web-application that allows for collaborative musical composition [San10]. Here, we can create music along with other people, using only the browser. Unfortunately, it has its problems. The interface is cluttered and difficult to use. One also needs to have basic knowledge of music theory to interact with the application. Even so recognizing the huge usability problems of this tool, it was mentioned because the idea is very close to the one that sparked this dissertation.

4.2.2 jam2jam

This project announces itself as a *"new instrument that can be used in a formal and informal music learning and performance settings"* [Art11]. It can be used collaboratively, in a local or remote network, where participants manipulate several instruments to generate sound and video effects. It is based on the concept of exploration and on the concept of improvisation. This tool was designed to be used by people who do not have any knowledge of music.

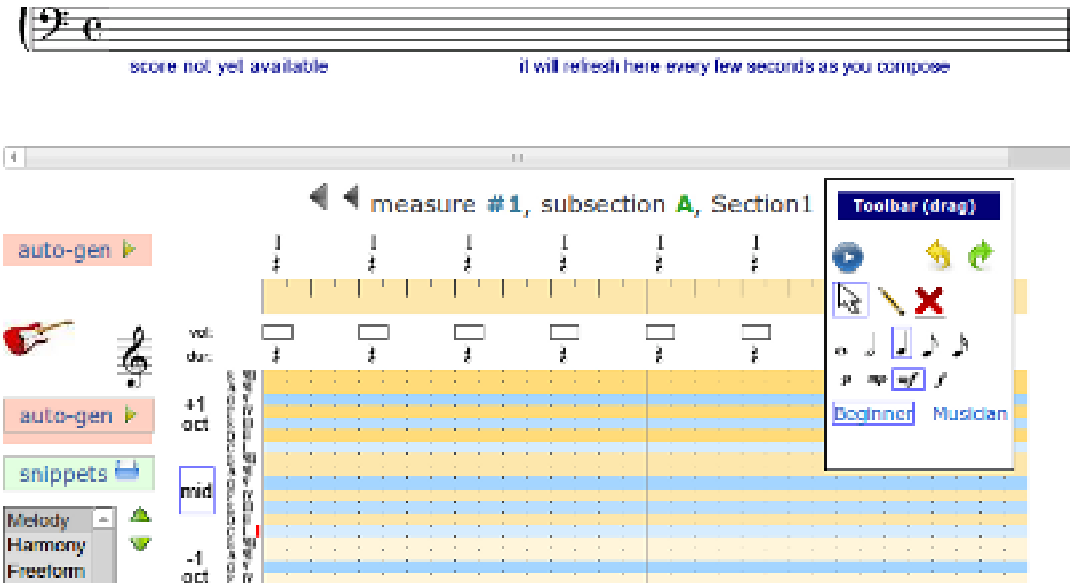


Figure 4.8: An example of Team Composer's canvas [San10]

Figure 4.9: OLPC Laptop running jam2jam XO [Chi11]

The interface has several circles scattered around the screen, where each one represents one instrument, and children can manipulate those circles to generate different sounds.

The interaction is extremely easy and intuitive, and it does not require knowledge about music. Also, the exploratory concept that is used here is really interesting. However, it is possible to manipulate existing samples, but not to compose them. Although this simplifies the interaction, it limits the available directions one can take when creating something.

One of the most interesting aspects of this project, is that it is integrated with the **One Laptop Per Child** initiative, whose goal is to provide poor children with a laptop, so that it improves its education [Chi11]. This means that children in under-developed countries that have the opportunity of being integrated in this initiative, have access to a very interesting music tool, that might stimulate their interest in the area.

4.2.3 Daisyphone

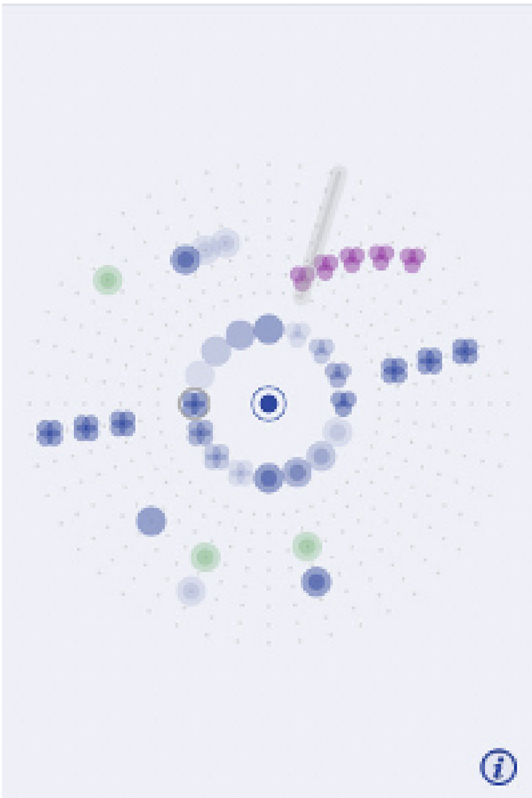


Figure 4.10: An example of Daisyphone's canvas [BK09]

Daisyphone allows people in remote locations to co-create music [BK09]. The application can be accessed through a browser, desktop or mobile, using Oracle Java®, or through an Apple iPhone® app. The interface contains a big circle in the middle where players can draw around and, as a rotating pointer passes through, similar to a clock pointer, it plays the sounds correspondent to the drawings. It is extremely easy to understand and to use, and it is extremely engaging, especially when composing with other players.

4.2.4 MOGClass

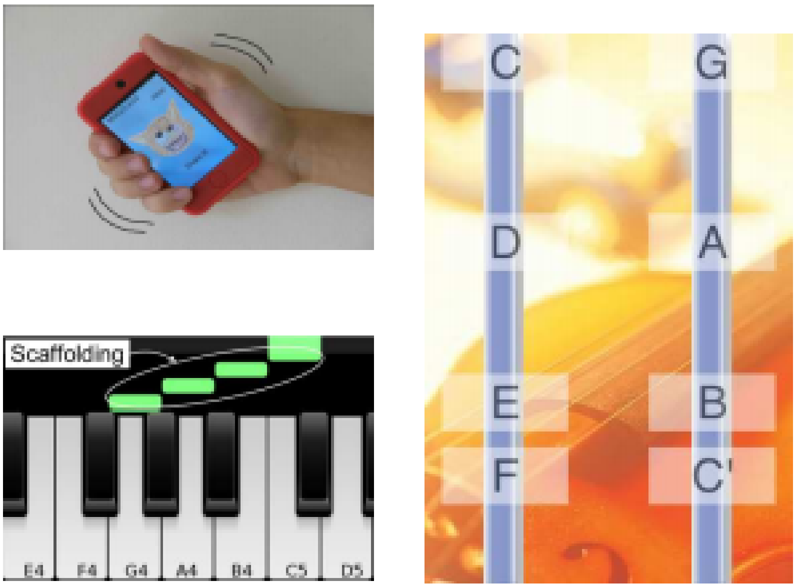


Figure 4.11: MOGClass interface for students [ZPW+10]

MOGClass is a system of networked mobile devices that allows the production and performance of music in the classroom [ZPW+10]. Both students and teachers have a mobile phone that are connected to a central PC, which plays the music. The students phones have three virtual instruments, which are simple to play and require no musical knowledge. The teacher can control some parameters of the students phones. The goal of this project is to enhance motivation, interest and collaboration in music classes.

The major disadvantage of this project is that the class must have a certain number of mobile phones, specifically Apple iPod Touch®, the platform for which the software was developed, and that can be out of reach for many schools. Other detail is that children have to be in the same network to collaborate, and they need to do it synchronously.

4.3 Summary

This chapter includes a set of different approaches to similar problems, some of which really interesting. About the non-collaborative tools, *Hyperscore* was, arguably, the simplest musical composition tool, but still being able to create complex pieces. Its paint-like interface uses children's previous knowledge in painting to make the interaction easier, allowing them to focus on creating the music rather than learning musical notation. *Toons Tunes* creates a social network around music. Although the social features were given more relevance inside the platform, they are using it as an excuse for children to immerse themselves in the world of music. From the non-collaborative group, *Isle of Tune* is a tool that uses a constructionist approach, creating a (micro)world where children can explore music creation through metaphors. This way, children do not see music notation as a 2-D graph where time goes left to right and sound is produced while a handle passes by the notes. *Isle of Tune* offers a 3-D world where children can interact with objects that are known to them: houses, roads, cars, et cetera; that, by making it easier to understand the relation between the objects and music elements, children can understand easily how to make music. *DrumSteps* showed how a simple microworld can be used to create complex and interesting sounds.

About the collaborative tools, *jam2jam*'s approach was really interesting, they only allow manipulation of the instruments, rather than composition. This makes using the tool easier, as children do not have to learn the tool's special notation. As mentioned before, this tool is integrated with the *One Laptop Per Child* initiative, and it is a great entry point for children who, until then, never had the opportunity to interact with such tools. Daisyphone's multi-platform feature is really interesting, as someone that is coming home in the subway can be making music with someone that is on the computer. The simple visualization and interaction are engaging enough by themselves, however it is the collaborative features that shine.

Some of these tools focused on the musical composition features, others focused on the social/collaborative features. However, none of them uses exactly the same approach this dissertation uses.

After understanding how others solved similar problems, this dissertation's problem can now be fully understood, and this takes us to the next chapter: Research problem and methodology

Chapter 5

Research problem and methodology

Now that the areas around the initial problem have been explored, the problem to be solved in this dissertation can be defined completely.

5.1 Problem definition and contributions

Section 1.2, A collaborative musical composition platform for children, by children stated that:

> (...) What this thesis proposes is (...) an **online platform** that will allow children to **compose music**, **collaboratively**, through an **exploratory** environment, with the goals of **stimulating** their interest in music, while **learning** some of the foundations of music theory.

Therefore, this thesis main problem is:

> How to create an interactive platform that engages children in the exploration of music?

To frame this in the literature, **theories of cognitive development** were explored, how can **children learn using collaborative technologies**, **how engaging experiences can be created**, **music**, and the **relationship between children and technology**.

Chapter 2, How children learn (and how can we learn about them), concludes that this work is based on two theories: Papert's **Constructionism** and Vygotsky's **Social Constructivism**. Constructionism says that, for learning to occur, children must be consciously engaged by what they are learning and that they must construct a public entity. It also introduces the concept of Microworld, where children interact with an environment defined by the rules and constraints of a certain domain, building knowledge about that domain. This way, **one can teach children music by letting them interact with an environment that follows music's rules and constraints**.

Social Constructivism states that learning is affected by the social context. A concept that is relevant to this thesis is the **Zone of Proximal Development**, which states that children that are unable to do a certain task can do it under adult or peer guidance. In other words, one has to take in consideration that **if children have difficulties in performing a certain task, they can overcome them if supervised or if they watch others do it**.

These theories are the foundations of this dissertation. After understanding how children learn and how this platform can help them engage in that process, one has to know exactly how to engage them in the activity. To do that, we must gather as much information as possible and work together to build a throughout understanding about them.

Chapter 3, Designing for children, with children, presented an overview of several methodologies that use participatory approaches, integrating children in the design team, so that we can create something suitable to their needs and interests, resulting in engaging experiences.

After considering all the advantages and disadvantages of this approach, **this dissertation will use the Participatory Design approach, including children in the design process**.

Based on this, this thesis contribution's can be defined:

- The introduction of collaboration in a musical composition tool to create better learning opportunities;
- The generation of a Microworld through the use of Participatory Design's methods;
- The creation of a research framework that serves as foundations for creative projects in similar contexts.

The project where this dissertation is framed has very specific requirements, which makes the definition of a new methodology, based on the frameworks and methodologies found in the literature, necessary.

Now that the problem and contributions are well defined, all that is left is to describe how to approach this work.

5.2 Design methodology

While selecting a methodology for a project, there are some variables that are common to all projects, such as time and resources. However, there are also some variables that are specific to the project at hand, that are of extreme importance to the selection of a methodology. None of the methodologies presented in this document were a perfect match for this dissertation's work due to differences in the **requirements and constraints**.

5.2.1 Requirements

To use a participatory approach throughout the design process successfully, some conditions need to be met.

The most important condition is to be in touch with a group of children as much as possible for a certain period of time. While establishing contacts with local schools, I immediately found out that the children's schedule is already very saturated with classes and activities. However, some of these activities are complementary, such as having a time-slot to do their homework supervised by the teacher. Luckily, most schools said it was OK to free up one of these time slots to carry out the research for this thesis. Each time-slot lasts about one hour and thirty minutes to two hours, depending on the school. Having such a short session only once a week would stifle my study, and would take too long to do it, considering the available time to execute this dissertation.

To solve this problem I decided to have two teams of children as designers, in two different schools. However, doing this also takes its toll. Every week, the activities have to prepared, and the results evaluated, twice - all this at the same time as including the results in the design and building the prototype.

A very important constraint that has not been discussed is that most of the studies in the literature, presented in the previous section, were done with the support of a multi-disciplinary team. However, this study was carried out by myself - only a team of one. This required the activities to be planned and executed by me. To solve this problem, the audio of the sessions was recorded, so that they could be reviewed for the case any detail was missed.

Another important requirement to define is how all the activities were planned. Since the sessions were short (with about one hour and minutes each), a long exposure with the children was needed. Also, other activities happened at the same time, such as the design of the prototypes and the implemention of a low-fidelity version of the platform.

The sessions lasted ten weeks, from research to final prototype. This totals fifteen hours of field work with each design team. This is a very limited time. Specific activities that enable me to get to the point spending the minimum amount of time will be crafted.

Related to the previous requirement, one of the problems foreseen in doing Participatory Design is that working with children is unpredictable. With this unpredictability, maintaining a regular work rhythm might prove difficult. Therefore, this methodology will have to allow for flexibility, in order to adapt the sessions on the fly, without hurting the final result.

The last requirement to discuss is the reward children are going to get from participating in the project. Instead of rewarding them with money or objects, such as toys, I will be teaching them about topics related to research, similarly to some examples found in the literature and presented in Chapter 3 Designing for children, with children. The teachers agreed with this pedagogic partnership, and were eager to send all the students to these activities.

At the beginning of each activity, the subject related to that activity is going to be explained. This explanation is followed by the activity itself, giving them an opportunity of experiencing it hands on - learning by doing. After the activity, or in the beginning of the next activity, a small debrief of the previous activity will be done, to allow them to relate what they experienced to what I explained.

With these requirements and constraints in consideration, it is time to define the methodology *per se*.

5.2.2 A Rigidly Flexible methodology

The methodology chosen that I named as Rigidly Flexibe is based on Allison Druin's **Cooperative Inquire** [Dru99] and Michael Scaife's et al, **Informant Design** [SRAD97].

In her studies, Druin *et al* used, as the previous section describes, three basic techniques: *Contexual Inquiry*, *Participatory Design* and *Technology Immersion*.

Regarding Contextual Inquiry, it was not possible to incorporate it in the methodology because of the available time each session has. In order to collect data about the children, and the context of this project, other methods were used. Those methods will be described later in this section.

The second technique described in Druin's study is *Participatory Design*. This forms the foundation of the design stage, where the design will always be made alongside children. The activities inside this stage are going to be specified later in this document.

The third and final technique, *Technology Immersion*, was also incorporated in the methodology, as one can observe children interact with other existing technology. The technology to be used is related to music, in order to learn not just how they interact with it, but also how they perceive musical concepts.

However, it was in **Informant Design** that this methodology was structured upon. Scaife *et al* define Informant Design as a framework, and divide it in four phases: *Problem and Domain Definition*, *Translation of Specification*, *Design of Low-tech Materials* and *Test, Design and Test Hi-tech Materials*.

In the first stage, Problem and Domain Definition, the goal is to understand the problem space. This will represent the research stage of this methodology, where activities with both teachers and students will be done, to build a better understanding of the problem in hands.

The second stage, Translation of Specification, translates the abstract problems identified in the first stage to prototypes. In this framework, the designer is the one who has the task of bridging the abstract problems and the prototypes. However, in this case, the design will be made alongside children.

The third stage, Design of Low-tech Materials and Test, is responsible in evaluating the prototypes and iterate the designs. The evaluation of these prototypes is based on a set of assumptions.

In the fourth and final stage, Design and Test Hi-tech Materials, the team tested a hi-tech prototype both with children, to evaluate interface problems, and with teachers, to evaluate the value it would bring to the classroom. In this methodology, there will be no distinction between the evaluation of low and hi-tech materials.

Now that the foundations of this methodology are clear, a description of how they were structured and what this dissertation contributed to them follows.

This methodology is called **Rigidly Flexible** because of a combination of requirements stated by the previous section.

This methodology has a rigid set stages, to ensure that the work flows until the final deliverable, but each stage should be flexible enough to change the activities as they are done, so that they can be adapted to the unpredictable changes that happen throughout the process.

There are three rigid stages:

1. Understanding the children's perspective (Domain and Requirements Definition)

2. Solving the problem, alongside with children (Idea Generation and Participatory Design)

3. Prototype Design and Evaluation

Picture 5.1 portrays a diagram with the relationship of these stages.

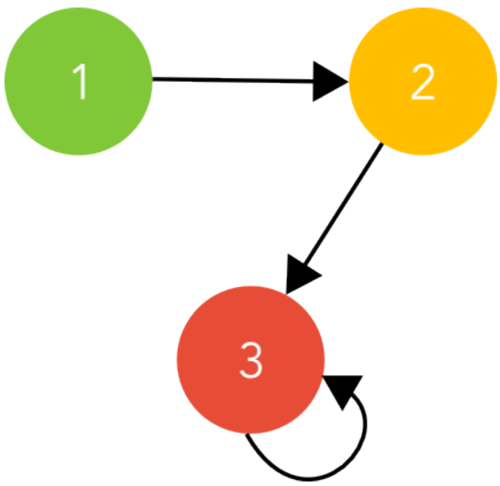


Figure 5.1: Diagram of the methodology

1. Understanding the children's perspective

The goal of the first stage is to do research activities, to understand the context of the project and to learn more about children.

These activities will be structured to answer three questions:

1. How do children perceive music?
2. How do they interact with technology?
3. How do teachers see music and technology?

The result of these activities will be a set of information that will allow these questions to be answered, making the problem space clearer and the domain defined.

The practical result, or deliverable, of this stage is a set of **personas**. A persona is the representation of a real person that is *"based on the behaviours and motivations of real people we have observed and represent them throughout the design process"* [CC07]. In other words, these personas will condense the data and observations that resulted from the activities in a simple form, so that they can be used throughout the process to support design decisions.

2. Solving the problem, alongside with children

This is the critical stage of this project. At this time I will have a pretty good idea of what needs to be built, based on the results of the research stage, and I will work with children in Participatory Design sessions to define the general concept (the Microworld) and the first details of the platform.

The number of sessions is undetermined, and they will be structured on a weekly basis, due to the afore mentioned unpredictability of working with children.

All the activities taking place in this stage have the same structure, but different goals:

1. **Defining the Microworld** - the first goal is to define the Microworld, through activities that will involve brainstorming and quick prototyping sessions, so that the children's imagination can be stimulated to create a solid concept that is adapted to their needs;
2. **Defining the requirements** - after the Microworld is defined, there will be sessions for kids to imagine what they could do in such a platform. This will give a rough idea of what they want, so that the projects goals can be validated and built upon;
3. **Designing the platform** - finally, alongside the children, some of the ideas that came from the definition of the requirements will be designed. They will result in a low-fidelity prototype, that incorporates the concept and the requirements, from which the children can give their thoughts and iterate the design.

After achieving these goals, a low-fidelity prototype will be ready to be evaluated with children.

3. Evaluation

The third and final stage consists in evaluating the prototypes developed in the previous stage. These prototypes are going to be evaluated with other children than the ones on the design team, as they are too involved with the concept so that the results are not influenced by their contact with the prototype or the ideas in that prototype.

The first step is to evaluate a low-fidelity prototype, made with basic materials such as paper and coloring pens.

After analysing the results of this evaluation, the prototype will be iterated as much as needed. As iterations go by, the fidelity of the prototype will increase, passing from drawings in paper to a virtual interactive prototype. In the context of this dissertation, this is the stopping point. The virtual interactive prototype will be the bare-bone of the final implementation, serving as part of the design specification.

5.2.3 Summary

The methodology chosen for this thesis is based on Allison Druin's Cooperative Inquire [Dru99] and Michael Scaife's et al, Informant Design [SRAD97]. However, it was adapted to the specific requirements of this project resulting in a rigidly flexible methodology. It is composed by three stages: i) understanding the children's perspective; ii) solving the problem, alongside with children and; iii) evaluation. Inside these stages, the activities taking place will address a set of goals, so that the activities can be adapted to the pace of the sessions.

This methodology is also the structural foundation of this study, and it will be the guiding light throughout the project. It was created to be flexible, as working with children is somewhat unpredictable, allowing the direction to be changed easily without disrupting any of the stages.

Being a team of one is not going to be easy, since there is only one person to plan the activities, execute them and collect the data - twice a week. Possible interruptions of the sessions, due to holidays and other events, also have to be taken into account.

A fact worth mentioning is that a music teacher will be following the whole process, to guarantee the musical value of the produced work.

Finally, a partnership with two schools was made. Both schools are public, and offer music classes given by a specialized teacher. **The work will be done with the same classes throughout the whole process, to guarantee consistency in the results**.

Now that the methodology is defined, everything is ready to actually execute it. The next three chapters follow the structure of the methodology, each one representing one of the three stages, in order. They will go into detail about the activities executed, from their planning to the results.

Chapter 6

Understanding the children's perspective

The first stage of this project has the goal of understanding the children's perspective regarding their relationship with music, musical technologies and learning in general. In other words, this stage consists of the **user research**, giving a solid foundation for the design stage, and the rest of the project. The main takeaway from this stage is a set of personas, which will guide the design and development process.

As the Design methodology section says, three questions need to be answered:

1. How do children perceive music?

2. How do children collaborate to interact with technology?

3. How do teachers see music and technology?

In order to answer these questions, a set of activities were crafted. The structure of this chapter follows the order in which these activities happened. This way, the reader can see how the information collected kept shaping the author's perception over time.

Also, all the chapters that describe the methodology will be narrated in first-person in the past tense, since it reports a personal experience.

6.1 How do children perceive music?

When one masters a topic, lets say music, one has a clear vision of how all its pieces fit together. However, this is not the case with children, who do not see the whole picture. Actually, as this section will demonstrate, children hardly have this knowledge at all. To understand how children perceive music, I planned two different activities: **interviews with children** and **pictorial expression**, as described in the next sessions.

6.1.1 Interviews with children

In this activity, my goal was to understand how children relate to music, both at home and school, from their perspective. Based on Druin's **Cooperative Inquiry**, I decided to do **Contextual Inquiry**. As described earlier, "Contextual Inquiry is a methodology that states that researchers should collect data in the users own environment" [Dru99], and this is what I did.

In this activity, I went to both schools and organized a set of ten minute interviews with children aged between eight and nine. At these ages, children's social skills are not fully developed yet [PI69], so I had to make sure they were comfortable during the interview in order to get useful answers. The first thing I did was to choose the right place for the interviews. They took place in the school library, as the teachers found that it was an environment children were familiar with. However, although they were in a familiar place, they still might be intimidated with being alone with an adult. Instead of making one-on-one interviews, I decided to interview them in pairs. This way, having the presence of a classmate, they were more likely to feel more comfortable talking with me.

In total, I managed do make ten different interviews, with a total of twenty kids. The kids were chosen randomly from a third grade class, with about the same number of males and females.

The interview contained questions such as: *"What does music represent to you?"*, *"How do you think music is created?"* and *"Do you see any relationship between making music and painting?"*. To see the full session script, please refer to the Appendix A, section Interviews with children.

After the interviews, I compiled all the answers and drew my conclusions about them. Since I only visited two different schools, whose students are in the same social stratum, these conclusions are not representative of all children. Despite this, the goal is to understand how they view the problem, not detailing precisely the average opinion of all children.

Before jumping into the conclusions, I wanted to state some things I learned throughout these interviews.

One situation that happened often was that, after I asked a question, there would be an uncomfortable silence. This silence could have two causes: i) the child could be thinking; ii) the child could be embarrassed, and did not want to answer. The first case is a hard situation, since breaking the silence might throw the child off and get an untruthful answer. In the second case, the author's experience showed that breaking the silence by encouraging the child, or trying to ask the same question with different words, might help.

Regarding their answers, a situation that happened quite often was that they gave shallow answers, such as: "cool" or "fun". This might be an evidence of nervousness, as they might not yet formulated a proper answer and they feel they need to do it. I tried to make them comfortable by giving them more time, and when I got such shallow answer I would try to dig deeper, to get a more insightful answer.

Finally, kids talk, a lot. During the interviews, often I found myself talking with them about random things that popped up in their heads. They can get lost easily and it was hard to keep them in track without interrupting them. Every time this happened I just switched the conversation with sentences like "okay, lets focus on what we are doing" or "we are running out of time, lets return to what we were talking about".

Results

Regarding music, the results of the interviews show that children associate it with three activities: i) hearing, ii) singing and iii) dancing. All three are interpretation activities. This might be the reflex of what they do at school, based on what I learnt in the How do teachers see education, music and technology?. Independently of the activity, fun was a word that came up a lot during the interviews, as well as physical activity. This was particularly interesting, as they told me about activities they did in the playground, or in school festivals, that involved group dancing and singing.

One of the most interesting results is the way they relate music to **emotions**. When describing what music meant to them, children used words such as **passionate, inspiring, cute, sad and lively**. Even without knowing much about music, they are able to extract the emotion associated with a particular music. **This emotional aspect is something I will be looking for in the next activities.**

As said, children relate music to interpretation activities. When confronted with questions related to musical composition, they knew little about the creation process. Mastering a musical instrument takes a lot of years, and even then passing to musical composition depends not just on the technique, but also on the individuals creativity. Despite this fact, as shown in the How do teachers see education, music and technology? section, teachers are not really sure on how to approach composing in classes.

Although children do not know how to compose music, they have a notion that it demands some specific skills, such as **teamwork, patience, rhythm and attention**. The last three skills might come from their class activities, such as dancing, where one must be in the rhythm, therefore alert to the music. It was the first skill, however, that caught my attention. They related the act of music creation to a band, and this was made clear in the activity I am going to talk about next.

Finally, I also wanted to understand if and how their households influenced their perception of music. All the kids who said they had someone on their family playing an instrument were more comfortable with music subjects, even going as far as wanting to learn an instrument. This shows that children are influenced by their families' relation with music, and can be determinant.

I also wanted to learn more about their habits regarding technology. Due to a government initiative in Portugal [dE11], most of the kids have a personal computer. Besides this computer, they also have other computers at home, usually the parent's computer. However, it was in school that I found inconsistencies. One of the schools I visited had a cutting-edge computer classroom that was not being used because there was the need to create a new class due to the school's overcrowding. The other school did not have a computer classroom at all, just a few old computers at the library. However, every child that participated in the interviews said they used a computer regularly. Most of their computer activities were related to entertainment, such as playing games, watching videos and talking to their friends. Only a small percentage did not have internet at home. However, as I said in the beginning of this section, this study is not representative of all the children of the target group.

The last subject I tried to get information about was collaboration, and how they felt about it. At school, children feel they rarely work in groups. However, this is the type of work they enjoy the most. When asked why, most said it was because they could talk to their classmates, or it was easier because someone always did the work for them. Nevertheless, in my opinion, this shows their predisposition for collaborating.

However, I still wanted to know how they really felt without the pressure of an interview. So, at the end of each interview, I asked them to make me a drawing at home. This takes me to the next activity.

6.1.2 Pictorial expression

After doing the interview I asked the children to draw me something that would show specifically **what music means to them**. The goal of this activity was to get a unbiased pictorial representation of what they feel about music. Unbiased, because the pressure of the interview might influence the answers they gave me. This way, I allowed children to express themselves in a language they feel comfortable with, drawing, in an environment they feel comfortable at. This allowed me to validate, or not, the conclusions I took from the previous activity.

To take conclusions of the drawings, I observed the details of the drawings and tried to find patterns between them.

One of the things that stood out was the happiness portrayed. I could see this in the colors, the faces of the people and their activities. This confirms the emotional aspect I referred before - they relate music to happiness. A huge majority of the drawings portrayed people dancing and singing. This might also show the influence school activities have in their opinion.

Another thing that I found interesting was their perception of musical instruments. In addition to the most common instruments, such as guitars, drums, flutes and pianos, they also drew less common ones, such as trumpets, glockenspiels and violins. This might happened because of relatives playing those instruments, but I could not confirm this.

(a) (b) (c) (d)

Figure 6.1: Examples of the drawings produced in the Pictorial expression activity

Funnily enough, although they portrayed instruments, children also drew speakers and sound waves, or even musical notes (that show they know music has a language, even if they do not know how to write it), coming out of the speakers, not the instruments. The reasons for this might be because of: i) the way they consume music at home - their computers, televisions or radios); ii) their perception of music concerts; iii) their contact with music concepts in textbooks.

For the full results, please refer to the Appendix A, section Pictorial expression.

6.1.3 Conclusion

Both these activities gave me plenty of interesting insights about children, their relation with music and even their daily lives. Instead of designing based on the assumptions of the author's experience, the decisions can be based on what was obtained from the target audience.

These activities show that:

- children relate music to three interpretation activities: singing, dancing and hearing;

- children can identify emotions is music;
- they are also influenced emotionally by music - they feel happy when they listen to it;
- their perception of how to create music is weak;
- children are able to identify several instruments;
- however, they portray the sound of those instruments coming out of speakers;
- their families influence their relation with music;
- children have one or more computers at home, as well as internet;
- their access to the internet, or even to the computer, is restricted;
- children, most of the time, use their computers for entertainment purposes (video-games, videos, *etcetera*);
- children prefer to work in groups at school.

There is one more stakeholder that can give valuable insights to this project: the experience of teachers. They experience this everyday, however they have the opposite perspective of the children, literally. This takes me to the second question: How do teachers see education, music and technology?.

6.2 How do teachers see education, music and technology?

One of the most important stakeholders in educational projects are the teachers. They are the ones on the front-line, the ones who experience everything first hand and that therefore can give extremely useful insights about the context of the project.

Getting to see their perspective on the topics of education, music and technology, not only makes me understand some of the insights obtained in the children's interviews, because of their direct influence, but also gives me new insights that only someone who experiences this reality on a daily basis can understand.

I decided I would interview two teachers, so that I could get two different experiences. Both teach in one of the elementary schools I partnered with, and teach different grades. The first one was a female teacher with eight years of experience. The second one a male with five years of experience. I interviewed both at the same time so that they could build on top of each others answers, generating discussion and sparking new insights. The interview lasted forty minutes and it was made in a classroom. The full session script and results is in the Appendix A, section Interviews with teachers.

A consideration that has to be made is that the results I am going to present next are based on the Portuguese school system, and they might not apply to other countries. Even inside Portugal, and as we will see next, the conditions are not the same for every school.

Music and technology in elementary school - the Portuguese case

The main thing I wanted to know was in what way is music present in elementary school.

However, I first have to give some context of the musical education context in Portugal.

In the Portuguese educational system, there is one main teacher responsible for teaching all subjects. This teacher can have assistants specialized in a certain subject, such as music, gymnastics, *etcetera*. The Portuguese curriculum of the year this dissertation was written contains, besides the mandatory classes, such as Portuguese Language, Mathematics, a set of courses called **Curriculum Enrichment Activities** (freely translated from the original name *"Actividades de Enriquecimento Curricular"*). Each school is responsible for choosing these curriculum enrichment activities they want to offer their students, these activities being subsidized by the government.

As I said in Design methodology, in this particular school, children had music classes from first to fourth grade with specialized teachers.

The goal of these teachers is to train good listeners. All the activities performed during class contribute to this goal. The thing that worried me the most was that the learning goals of music classes were different between teachers. The teachers do not have a rigid program to follow, given by the government. Instead, they have a set of guidelines. This means that the quality of music education children have is uneven, and even more dependent on the teacher than usual, if compared with the remaining subjects. This is a challenge, since children at the same age could: i) know nothing about music, if their school does not choose Music as a Curriculum Enrichment Activity; ii) know something about music, but that something might not be the same as another kid from another school. This means that, due to this variability, **we cannot assume children have any knowledge in music**.

Besides the program of the course being different between schools, they also do not have the same resources. As one school might have a big set of instruments, another can just have one or two. This requires the teacher to adapt his program to what he finds at each school.

Moreover, in the particular case of these teachers, both are on one year contracts and will probably change schools in the end of the year. This raises some issues: i) first, they are not able to follow the same class from the first to the last year; ii) they also have to go through an adaptation period in the beginning of the year in order to evaluate the level that a particular class is at, since there are no standardized goals and they have no way to know where the previous teacher left them.

Moving on to the teaching itself, these teachers believe they brought creativity to school. Therefore, most of the activities, above all, they want children to express themselves. Independently of the activity, they always try to relate music with things students liked. One example a teacher gave was that one of her kids likes football, so she tried to find a way to relate that to music, in order to stimulate interest in that particular child.

However, musical composition remains as a difficult subject to address. **Both teachers said they struggled to do activities that allowed children to create music**. This presents an opportunity for this work to succeed in a school environment, although that is not the main goal.

Finally, I shed some light in questions about technology. I wanted to find out if they used technology in the classroom, and how. Both teachers said they only use the computer to play music. I was expecting they used music tools, such as software for children that was already available, but both said that they really do not have much time for that. This is due to the little time this course has allocated per week.

Again, interviewing these two teachers was an excellent exercise that enabled me to see music education from their perspective, even if was just for a few moments. In this particular topic, I had a lot of assumptions that were proven wrong by this interview. I also learned a lot about the learning goals, which will be useful while designing the platform.

As I said in How children learn (and how can we learn about them), the Portuguese government wanted every child in Portugal to have his own laptop [dE11]. Three years have passed since the first distributions, and we may now have a new generation that is extremely competent in using technology, but, again, I cannot assume anything. That takes me to the next section: how do children collaborate to interact with technology?

6.3 How do children collaborate to interact with technology?

With the third and final question, I really wanted to understand how children interact with current technology, collaboratively. Today, children are born with technology all around them. They are learning to interact with them at the same time as they are learning to walk and talk. They are the Digital Natives [BK08].

However, I really wanted to see *in loco* how they interacted with it. In order to do this, I planned one activity, called **technology immersion**.

Technology immersion

This activity was inspired by a technique presented by Allison Druin in **Cooperative Inquiry**. As explained in Design methodology, this technique consists in the observation of children using technology for an extended period of time [Dru99]. However, I felt I did not have the need of doing that for such extended period of time, as I was not looking for patterns or insights about new technologies, but instead was observing how easily they could interact with technology with each other.

In this particular case, I presented the kids with a music game called **DrumSteps**, described in Chapter 4, on DrumSteps. This game has a lot of similarities with the platform I am proposing, to the extent that it incorporates a lot of the philosophies I want to incorporate. The game uses the metaphor or dropping a ball onto steps and ladders to create percussive sounds. I have chosen this game as I found it had an easy learning curve, enabling smaller learning sessions. This activity had twenty minute sessions with groups of three classmates aged between eight and nine, with an equal number of males and females. In total, I had eight sessions, totalling twenty four kids.

The full session script and results is in the Appendix A, section Technology immersion.

The first thing I observed in all the groups was how intuitively they interacted with the game. They knew what was clickable and what was not, they could even predict the outcome of their actions. Regarding the interaction with the computer, it was extremely natural. A pattern I found interesting was that, although I had an external mouse, most of them preferred to use the trackpad of the laptop. This might have happened because of the way they use their own computers, or other computers at their homes. Moreover, it can also be because of the natural interaction it provides- if we want to move the mouse, we just move the finger; if we want to push on something, we just push the trackpad. However, some of the kids who tried the mouse first had some problems, specially the ones who had small hands. This problem might be due to the mouse size, but it still is a problem.

Another aspect I noticed is how amazed they were with the graphics and animations. When they saw the little ball coming down hitting all those steps and producing sounds, they were amazed. This really engaged them, so much that they started placing as much steps as they possibly could, even if the ball never passed there.

Regarding the interactions with each other, I also found many interesting behaviours. The first, is that in almost all groups there was a leader, who picked up the mouse right after I told them they could start playing the game. He was typically individualistic and wanted to do things his way. Some started arguing and, eventually, sulk. To counter this behaviour, I gave every kid the same amount of computer time. However, it allowed me to see that I should be careful in the design of the collaborative features of the game, as it may cause frustration.

Despite this behaviour, some of the groups collaborated great and, while one controlled the game, others gave ideas. When it was their turn to play, they instantly knew how, although they were only seeing others play.

Finally, and still in the subject of behaviours, one thing that happened was that if one takes too much time doing something, the others would get bored and, eventually, frustrated. This tells me the control of the game should be asynchronous, wherever possible.

Technology Immersion was definitely the most rewarding one for the kids. They had an amazing time and, months later, they still remembered the game. This was extremely interesting to see, as one could not imagine that playing a game for twenty minutes could have such an impact.

However, the most important part were the behaviours observed. The way the collaborative features need to be carefully planned out, to avoid the bad situations that happened during this activity.

6.4 Results

After analysing the results of all these activities, I was left with a set of data from where I can extract patterns from. However, how can this data be useful to me?

As I said in Design methodology, at the end of the research stage I would use this data to build **personas**.

A **persona** is the representation of a real person that is "based on the behaviours and motivations of real people we have observed and represent them throughout the design process" [CC07]. Throughout the design process, I will refer to these personas to make decisions based on real data.

The process I used is based on the one described in Alan Cooper's **About Face 3** [CC07].

After condensing the results into bullet points, I extracted behavioural variables, based on the behaviours of my audience. The variables I identified were:

- Computer use - from work to entertainment;
- Internet access - from very little to very much;
- Group work skills - from individualist to team player;
- Music skills - from interpretation to composition;
- Music influence at home - from very little to very much;
- Learning an instrument - discrete variable: no, yes, in the future;
- Relates music to - discrete variable: emotion, action, music genre, instrument;
- Musical composition perception - from low to high;

Afterwards, these behavioural variables were mapped with the interviewees in a diagram, so that clusters of similar behaviours could be found, results in a set of personas.

This was the method used to create the personas that represented the children that participated in the described activities. In total, three personas were created:

1. **Bernardo Sousa**: an eight year old third grader passionate about music. He is computer-savy and uses his computer to play video-games;

2. **Maria Carvalho**: an eight year old third grader who loves soccer and painting. Rather than playing the computer, she prefers to play outside with her friends - therefore her computer skills are not well developed;

3. **Rui António**: a nine year old third grader who wished school was as interesting as his computer. Due to his disinterest in school, he failed last year, so he his repeating third grade. However, he is top of the class in what relates to computers.

The full profile of these personas can be seen in the Appendix B, Personas.

Finally, a persona that represents teachers was created. However, the process used to get this persona was not the same. Actually, this persona was extracted directly from the observations and from the teachers interviews. This persona does not actually represent a group of users. It is called an *ad hoc* persona [CC07]. *Ad hoc* personas are *structured similarly to real personas, but they rely on available data and designer best guesses about behaviours, motivations, and goals* [CC07].

This persona is called **Manuela Araújo**, a thirty year old elementary-level music teacher. She is passionate about creativity and to educate good listeners that are able to appreciate culture.

These personas represent the bridge of the research stage and the next stage: Solving the problem, alongside children.

Chapter 7

Solving the problem, alongside children

After laying this project's foundations, we actually have to build it. This is a critical stage of the process: the design stage. However, instead of solving the problem by myself, I will be working with teams of children.

As the Design methodology section says, I will be working with two different schools, therefore I will have two different design teams. I decided to do this because I only had an one hour and thirty minutes session with each group each week, and that is not enough for this dissertation's project to move at an acceptable pace. Therefore, each week I will have two sessions in different schools.

I planned to do the same activities in both sessions because:

1. I was interested in seeing the difference of the results between both schools;
2. planning the activities and analysing their results would not be feasible due to time constraints, I could not manage doing two different sessions every week;
3. I would teach children about research through the activities I would be doing.

In the first stage, I did an activity called **Pictorial Expression**, where I asked the kids to make a drawing for me at home. Since only part of them actually did these drawings, I could see who were the most enthusiast about participating in the activities. Those are the ones I invited to the design team. One of the teams had five designers, three boys and two girls, and the other one had six designers, three boys and three girls. It is important to note that I did not choose the team based on school performance, or personality - instead, I chose them for their enthusiasm in the project. This way I managed to build heterogeneous groups, each member having different experiences both at home and school, based on their initial enthusiasm.

Similarly to the previous stage, the number of sessions of this stage was, at first, undetermined. As stated in Research problem and methodology, I had three goals:

1. Defining the Microworld

2. Defining the requirements

3. Designing the platform

With these goals in mind, I planned the activities in a flexible manner week after week.

One of the problems I feared was that the teams might feel disengaged with the activities being performed. Not because of the activities themselves, but because they could miss the point of what we were doing. For this reason, I decided to create a little game, that lasted throughout the activities and that I felt contributed to their engagement with them.

I told them I was a secret agent, and that I was working on a top secret project. We were recruiting new agents to work on this project and, after studying several other schools, I found out that they were the best. They got to choose their secret agent name, a name for the team and a secret handshake. All of this was secret and only their parents and teacher could know about what was happening in the activities. In the beginning of every session, we would do the secret handshake and up til the end, we would call each other by our secret agent name. The kids were so excited by this that during regular classes some of them hid to do the secret handshake. In the end, they all got a secret agent card with their names and the projects name, so that they remember they were a part of it.

Another thing I did throughout the sessions that was recommended by several authors, was to dress casually [ZG03]. This way, children saw me as one of them, as opposed to their teachers that would wear white coats. This clearly left them at ease, as I also made an effort to talk to them before the session started. In one of the specific cases, a kid was constantly calling me teacher. In order to prove a point, I replied that I was not their teacher, but their secret agent colleague and we were all secret agents. The names of the teams are: *Detective Agency* and *Secret Agents*.

Now that the session guidelines are set, I will explain how I met each of the three goals I stated. This chapter is then divided in three sections, each one representing a goal: i) **defining the concept**; ii) **defining the requirements**; iii) and **designing the platform**.

The structure of the chapter follows the same timeline approach as the previous chapter, where all the activities are in the order they happened.

7.1 Defining the microworld

Up until now, no reference has been made regarding the details of the platform. This has a reason: I wanted to do **everything**, from concept to final product, with the children. So, this is the first step towards the platform *per se*: defining the Microworld.

In order to do this, I organized a brainstorm activity where my goal was to stimulate the children's imagination to prototype the maximum amount of concepts possible. This activity was named: **creating the instrument of the future**!

Creating the instrument of the future!

The goal of this activity was to introduce children to the concept of prototyping, by challenging them to create the instrument of the future. We will discuss ideas and then prototype them using simple materials, such as paper, pens, scissors and adhesive tape.

Because this was the first session, each one wrote an idea in a piece of paper and then drew that idea, alone. I felt they needed an introductory activity, and this gave me the chance to explain what brainstorming and prototyping is, in a simply way.

After drawing the idea, the owner had to explain the concept and how is the instrument played. The most common scenario was that children imagined the combination of existing common instruments, such as guitars, pianos and flutes, with other objects, such as flowers, or even human characteristics, such as a face, arms and legs, and voice!

After this introduction, we moved on to the main activity: designing, as a team, the instrument of the future. We brainstormed some ideas and then started drawing them. The first challenge arose, when the kids started drawing, on the same paper, their individual idea. However, one of the kids instantly said: maybe we should connect all the instruments with wires, and they will produce different sounds. Collaboration, at last!

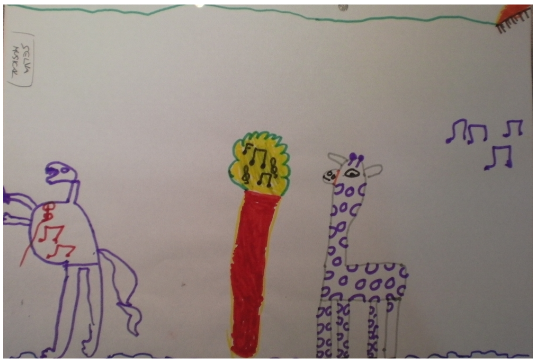
It was also during this activity that I started feeling the toll of being the only adult in the team. Besides participating in the prototyping activities, I also had to be alert to behaviours because, although I am not in the research stage anymore, I can also collect valuable data that I can feed back into my research.

In total, twenty-four concepts were drawn, from spit-firing dragons that produced musical notes, to giraffes that ate notes from trees.

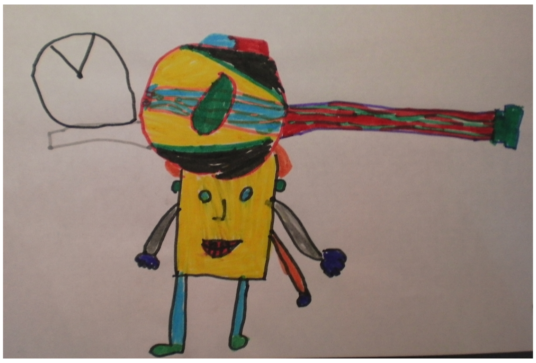
The full session script and results can be seen in the Appendix A, section A.2.1 Creating the instrument of the future.

(a) Several instruments connected with wires;

(b) A musical satellite controled by an alien playing the drums;



(c) A giraffe that produces sounds when she eats the musical notes on the tree, with a dinossaur that does the same;



(d) The man-guitar;

(e) A monster with seven heads, where each one plays a different instrument;

Figure 7.1: Some results of the Creating the instrument of the future activity

After the session, I collected all the concepts generated and drew possible versions that could work. At this point, I had a couple of ideas that could work, but I still was not satisfied with the results. Instead of repeating the same session, I decided that I would formulate a new session that would not only allow me to generate more concepts, but also to find out what features children might expect this tool. This takes me to the next section: Defining the requirements.

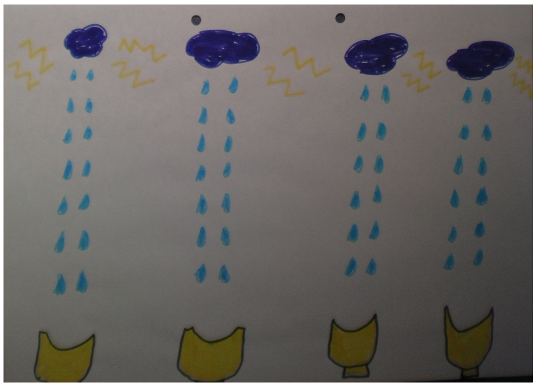
7.2 Defining the requirements

Although I had a couple of possible Microworld concepts at this point, I was still not completely satisfied with neither. I decided to work out the requirements and hoped the concept would naturally emerge - however, the conditions had to be set for this.

Therefore, I designed a session called "You should be able to...". Every idea should start with that sentence, so that, naturally, the idea could be turned into a requirement. The session started with a debrief of the previous session, so that I could explain what we have done and to help them make a connection between that session and the current one. It was followed by a thirty-minute brainstorm, where all ideas were written into a piece of paper. These ideas were then discussed, so that I could observe how they resonated with children, gathering their feedback about them. After the discussion, the best ideas were chosen and drawn together by the group. The result of this activity was a list of ideas, one hundred and eight between both schools, twelve of which were sketched.

The full session script and results can be seen in the Appendix A, section A.2.2 "You should be able to...".

(a) A giant monster that shoots laser beams to play music;



(b) A game where sounds are produced by rain drops;

(c) The dancing family game;

(d) Another dancing game;

Figure 7.2: Some results of the Defining the requirements session

Besides a set of possible requirements, that can be seen in the Appendix, I was also able to extract possible concepts for the Microworld, and from these possible concept emerged a perfect fit.

The microworld concept

In this session, there were some ideas that I could relate to the results I got in the research stage. Specifically, the ones that were related to singing and dancing. I immediately connected this to my research, where most kids referred singing and dancing as their favourite activities.

From the children's perspective, we should be able to:

- sing and dance;
- build a music-making theatre;
- make our own band and perform on stage.

Singing and dancing is something natural to most people, whether they are good at it or not. One of the drawings specifically portrayed a family dancing to the sound of a stereo. This, combined with the three ideas above, sparked another idea: they already know how to dance, and dance is extremely intertwined with music and its concepts - why not create a game where we have to make dancers sing and dance on a stage? The twist is: to make people dance, we have to make music!

Figure 7.3 shows the original sketch that sparked the idea:

In the upper half of figure 7.3, we have a stage with a *x* number of dancers (in this case, four), where each one represents a different music instrument. The goal is to create a **dance routine**!

In the bottom half of figure 7.3, this is how I imagined one made the person dance. The dancer is surrounded by circles that represent musical notes. To make a dancer move, we have to select a body part and make it *touch* a musical note. The combination of these movements is what makes the music.

To make the dance move, we have to create a sequence of movements. An example of a dance move is pictured by figure 7.4.

The dancer starts in an initial position. Then, he raises his right arm (our left), playing an individual note. Then, he raises his left arm, playing another individual note. Then he moves all the members, playing four notes. Finally, he moves his right arm and leg, playing two notes.

This concept is perfectly aligned with what I was looking for and it fits the Microworld theory. Children explore a world where they can interact with several concepts related to music, even

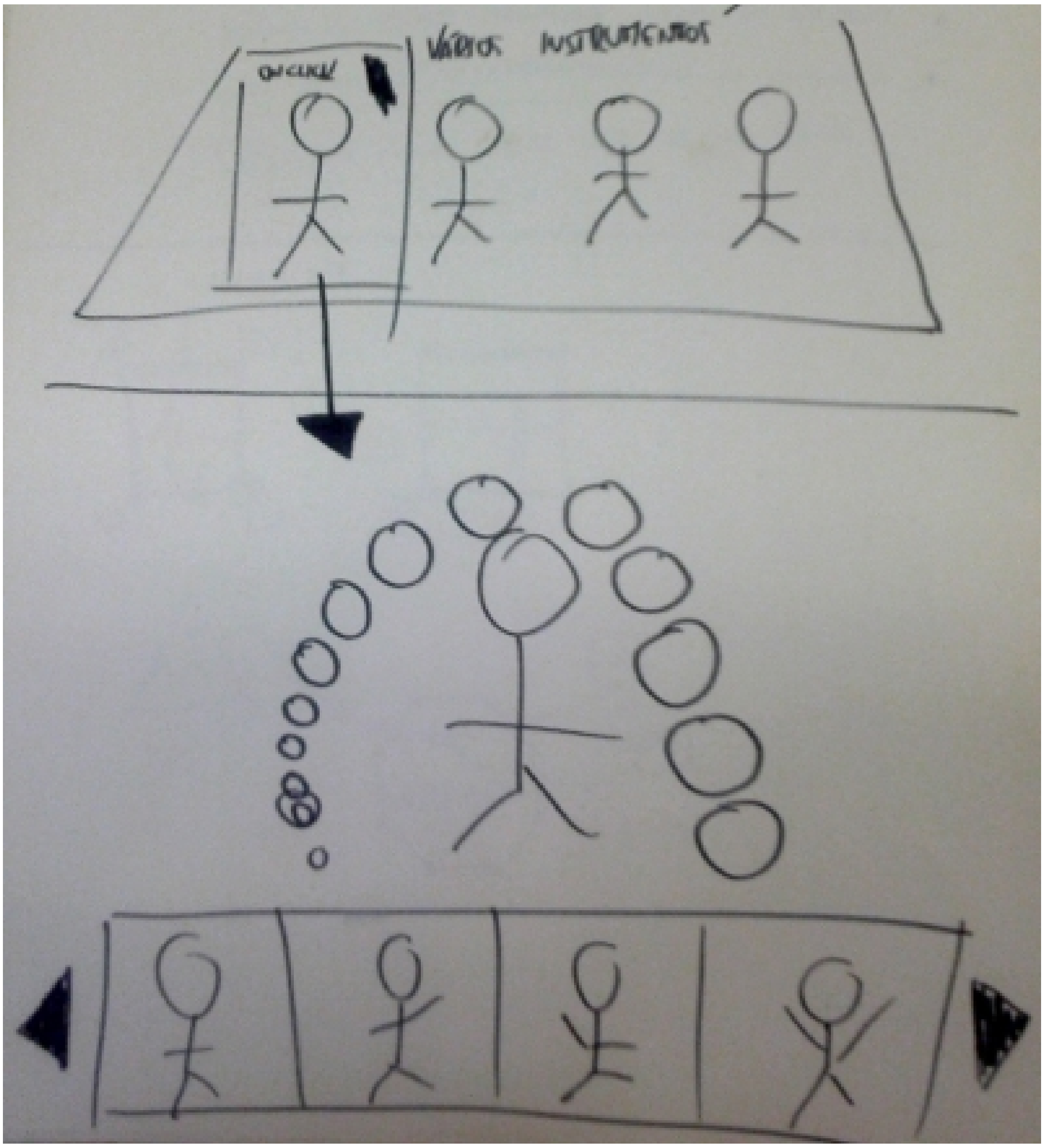


Figure 7.3: First sketch of the microworld concept

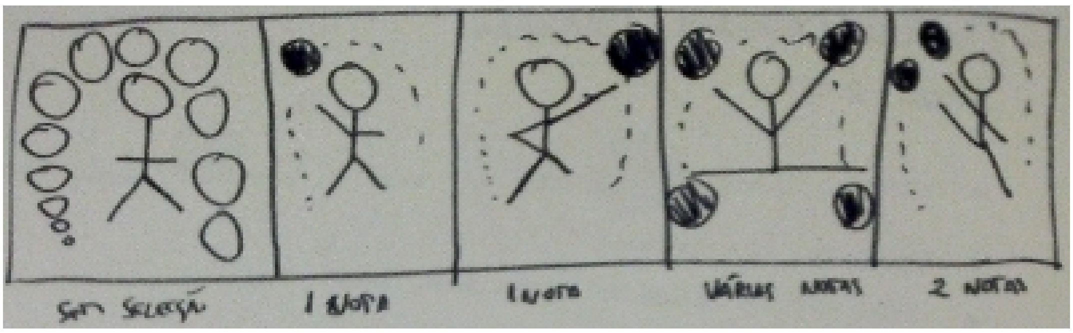


Figure 7.4: First sketch of the microworld concept - detail of a dance move

though they involve making a person dance.

The requirement ideas that were generated at this stage were archived until I started working on the prototype. First, I wanted to see how children reacted to the concept and how they built on top of it. This takes me to the next section: Designing the platform.

7.3 Designing the platform

Now that I have a concept and possible features for the platform, the goal is to design the first prototype.

As introduced in the previous section, I had an idea of the concept and how to interact with it. However, that was my perspective, and if I would have applied it that way I could have been wrong. I wanted to see how children reacted to the concept and how they would interact with it. For that, I designed a session called: **how do you do that?**

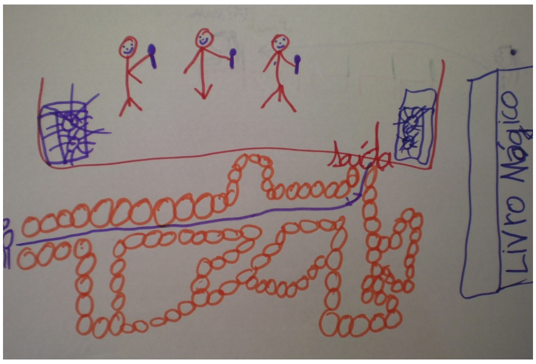
7.3.1 How do you do that?

Briefly, I showed them a low-fidelity prototype and I let them interact with it by asking them specific questions, such as: "What is this? What would you do?" or "How do you make the people dance?". However, that was not to evaluate the interface I had designed, but to observe children interacting with it **the way they think it is possible**. This might stimulate their imagination for novel uses of what I first designed, helping me improve it.

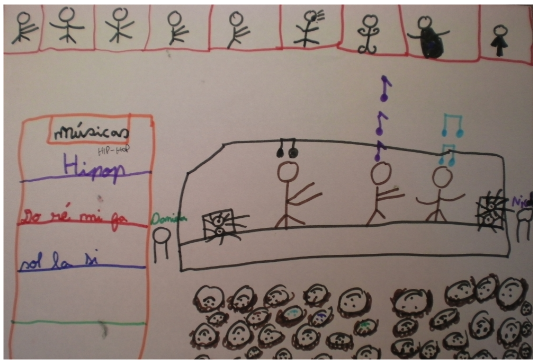
The full session script and results can be seen in the Appendix A, section A.2.3 How would you do that?.

After saying how they would do things, I asked them to prototype their ideas. This resulted in a number of drawings that could be considered possible solutions to the problems I presented them with.

This was actually the most productive activity, since the kids generated ideas that were both aligned with the concept and feasible. Some of the ideas were fed into the prototype, for that matter. The selection of these ideas was made based on their technical feasibility, compatibility with the concept, the experience they could provide (both in terms of usability and engagement) and their contribution to the platform's goals.



(a) A mini-game inside the platform where one has to solve a maze;



(b) An idea on how we should make the puppet dance;

(c) Another solution to the same problem;

Figure 7.5: Some results of the How do you do that? session

Seeing my own prototype with new eyes (theirs), I was able to iterate and to have something closer to a collaborative learning environment. However, there were some details I still needed to refine. To do this, I designed another activity called: **I Do Not Want To Be A Dummy!**.

7.3.2 I do not want to be a dummy!

Throughout the sessions, there were some recurring issues happening that disturbed the activities. The first was that kids would often get into fights because others ignored their ideas, disregarding them as "stupid". Then they would sulk and did not want to participate in the activity anymore.

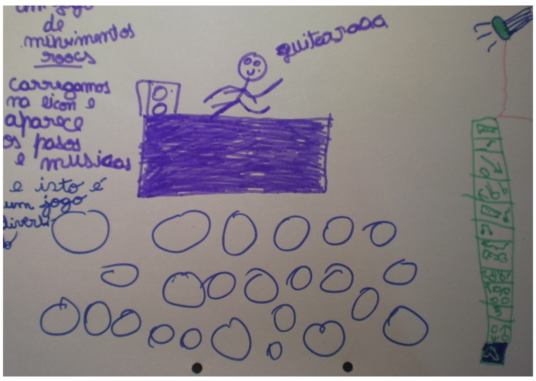
Another issue was when they were simply disengaged with the activity and started disturbing the colleagues that were interested. The first issue told me that kids were very competitive - although they are a team, and their efforts are always for the team, they wanted their individual ideas to shine. I thought I could use this competitiveness in my favour. The second issue was caused by lack of interest or distraction. I had to do something about it and find something that would engage them and capture their attention.

Therefore I designed an activity called **I Do Not Want To Be A Dummy!**. This was a game played by two teams, where I gave a problem and each team has to present one solution, guaranteed by all members of the team. Each team had to defend their idea in front of a jury, me, and the other team. The best solution was picked by me and that team would win a point. In the end, the members of the team with the least points would be dummies - and no one wants to be a dummy!

This way, I was able to use their competitive spirit to increase their focus and productivity in the tasks I gave them, while engaging them through a competition.

(a) An idea on how one could make several sounds at the same time;

(b) An idea that shows how we can make a dance routine;



(c) Another idea regarding the dance routine;

Figure 7.6: Some results of the I do not want to be a dummy! session

The full session script and results can be seen in the Appendix A, section A.2.4 "I don't want to be a dummy!".

The problems I gave them were:

- How do we make the dancer dance?
- How do we create a choreography?

Since I was not sure of some interactions with the platform, both problems relate to the user interface level. This gave me possible solutions to the problems, and these were used to iterate the prototype.

This activity worked great, since kids were, for the first time, defending their work and ideas. This made them realise that they really needed to think deeply to find solutions to the problems, or they would lose. Also, inside their teams, they collaborated better than with the whole group.

However, there was one thing that backfired. In the end of the session, one kid started crying saying he did not want to be a dummy. Maybe next time I will need to reward the winners, instead of punishing the losers.

7.4 Tying the loose ends

Before moving on to the prototype, there were some loose ends that needed to be addressed.

The first is related with the interface and the quality of the results children achieve using this platform. The stage where the dancers stand has a size limitation. We can only place x dancers without causing an overflow. Also, placing too many dancers on stage could make the music too complex. Therefore, I needed to limit the number of dancers on stage - but how? The number of instruments in a band depends on the genre of the music being played. In popular music, is often to see duos, trios, quartets and quintets. However, when we are talking about dance choreographies, we cannot say the same.

Therefore, the number of dancers in stage will depend solely on the size of the stage, disregarding the musical unbalance it might cause.

The second one is related with the collaboration between the players. As I referred in the previous section, I learnt throughout these sessions that children can quickly turn collaboration into competition. Therefore, the collaborative aspect of this tool has to be carefully thought out.

At the moment, I decided that the dance moves are, at first, created individually, therefore assigned to an owner. Later, they can be edited by anyone, although they are encouraged to discuss it first, through a chat feature, with the owner of that move. Regarding the choreography, anyone can arrange the dance moves, independently of who created those moves, or even who started the music.

This way, everyone has the same permissions, even who started the music, and they have ownership of the dance moves they create.

Also, the game will be asynchronous. Each player will be in different states of the game, of their choice.

These features must be evaluated, and I will address them again in the next chapter.

Finally, there is one issue that needs to be addressed. In what degree will teachers be involved with the creation process? I decided that, initially, the teachers will only have a passive role being spectators. This way, they can comment and discuss what children are creating, but they cannot manipulate it directly. The logic behind this decision is based on the fact that this is a tool, and there is no right or wrong way to use it. Although some creative decisions can be influenced by them, I do not think the teachers should be able to influence the final result directly - that is the students decision.

7.5 Summary

These sessions gave a clearer understanding of what children envisioned, resulting in a prototype. This prototype is based on all the work that was made until here - from the user research results to the participatory design ideas.

Having solved the problems that needed the direct input from children, I considered I reached a point where the platform's concept is well defined and aligned with the children's and teachers' goals. Now the concept needs to be transformed into a prototype, so that it can be evaluated. That is what the next chapter, 8 Prototype design and evaluation, is going to describe.

Chapter 8

Prototype design and evaluation

Having a solid understanding of children's needs and expectations, all the ideas generated in the previous stage were gathered and resulted in a low-fidelity prototype that can be iterated and evaluated.

This prototype will be, at first, made with paper, because this allows much faster iterations than if it was actually being implemented [War09]. However, a small part will be implemented so that it can be evaluated properly.

As with the previous chapters, this chapter follows a timeline structure, representing how work happened throughout time. Therefore, we will see how the prototype was being shaped by the results obtained in the evaluation sessions.

Although the prototype is illustrated by the use of pictures, it may be difficult to understand how the portrayed pieces fit together. Therefore, reading this chapter does not exempt the use of the actual prototype.

The first section of this chapter will deal with the prototype itself, explaining its different parts and justifying all design decisions.

The remaining sections will represent each evaluation session, all following the same structure - **introduction, results, iteration** - where the introduction contains what was tested and how; the results shows what went right/wrong; and, finally, the iteration represents how the prototype changed, based on the results the session yielded.

8.1 The first prototype

There is one important aspect that influences the whole game: instead of creating a continuous dance routine for a dancer, we create individual dance moves, where each move is a sequence of movements. Then, we arrange a collection of dance moves sequentially to create a routine. To simplify these relationships, we can see a routine as a paragraph, a dance move as a word and a movement as a character.

This was done to simplify the way one constructs music. Instead of creating a sequence of moves and *silences* (where a silence is the ausence of movement), one creates a sequence of moves. It also helps children to homogenize the musics, because it encourages the re-use of dance moves.

8.1.1 Requirements

Chapter 2 explored some theories of cognitive development, and some theories regarding collaborative learning. Standing on the shoulders of giants, two very important guidelines were established:

1. the platform should follow Papert's Constructionism, specifically the **Microworld** theory;
2. the platform should have collaboration features, that follow the studies of **Computer Supported Collaborative Learning** and Vygotsky's **Social Constructivism** theory.

Regarding the first guideline, Papert says that children must be consciously engaged by what they are learning [Pap93]. One way of providing this engagement is to present children with a concept they are familiar with and naturally engaged. During the design process, a concept aligned with what Papert says emerged: **dancing** and **singing**. Second, Papert says that by constructing a public entity, the artifact causes conversation that in its turn creates knowledge structures [Pap93]. This public entity will be represented in two ways: the entity will be constructed **collaboratively**, therefore subject to conversation that improves knowledge structures; and the final result should be **shareable**. Papert's microworld is an environment defined by the rules and constraints of a certain domain that allows children to explore that domain and understand the concepts behind it [Pap93]. The dancing metaphor fits in this description, as it is also subject to the rules and constraints of music, while doing a different activity. This way children will be interacting with music while thinking they are making a puppet dance.

Second, we have Vygotsky theory of **Social Constructivism**, specifically the **Zone of Proximal Development** [Vyg78], and the **Computer Supported Collaborative Learning** [Kos96] research area. Both are supported by **collaborative features**, that allow children to learn by: i) watching others doing it; ii) communicating and criticizing each others' work.

Finally, in Defining the requirements an activity to understand what children would expect from such platform was described.

The combination of all this with the author's own ideas of how the platform should be, based on the defined goals and the proposed guidelines, results in a set of requirements that will guide the design. Here, it should be possible to:

- create as many dancers as desired, where each corresponds to a musical instrument;
- create dance moves for a dancer;
- combine the dance moves of each dancer into a routine;
- play both single notes and chords, or none at all (silences);
- see clearly how a musical compass works;
- see clearly the difference between musical notes;
- explore the notes and their different combinations as they wish;
- communicate with all players;
- see what other players are doing;
- export the music and/or the dance routine;
- be a spectator in the creation process;

These requirements were validated with the **personas** developed in the end of the first stage. This validation meant to fill in any gaps that might have existed.

After the validation, all that is left is to build the actual prototype and to evaluate it.

8.1.2 Prototype

Based on the concept presented by the The microworld concept section, and the requirements, this prototype will have two main areas:

- The dance stage - where the players will assemble, collaboratively, the dance moves into a routine. The requirements that fit in this area are: create as many dancers as they wish, where each corresponds to a musical instrument;
  - create dance moves for a dancer;
  - combine the dance moves of each dancer into a routine;
  - see what other players are doing;
  - export their music.
- The dance move editor - where the player will be able to create and edit a dance move. The requirements that fit in this area are:
  - play both single notes and chords, or none at all (pauses);
  - see clearly how a music compass works;

– see clearly the difference between musical notes;

– explore the notes and their different combinations as they wish;

This platform has one specific goal: to compose music. Therefore, the **dance move editor** was the part that got more time allocated to because it is the most delicate part of the prototype, and it needs to be evaluated and iterated often. This prototype is focused on the essentials, there fore having a coarse granularity - this means that only the most essential parts are represented, due to its importance in the bigger picture. Other details will be left to the end.

Based on the first drawings shown in the previous chapter, a **non-functional low-fidelity** prototype of the dance move editor was created, that can be seen in figure 8.1.

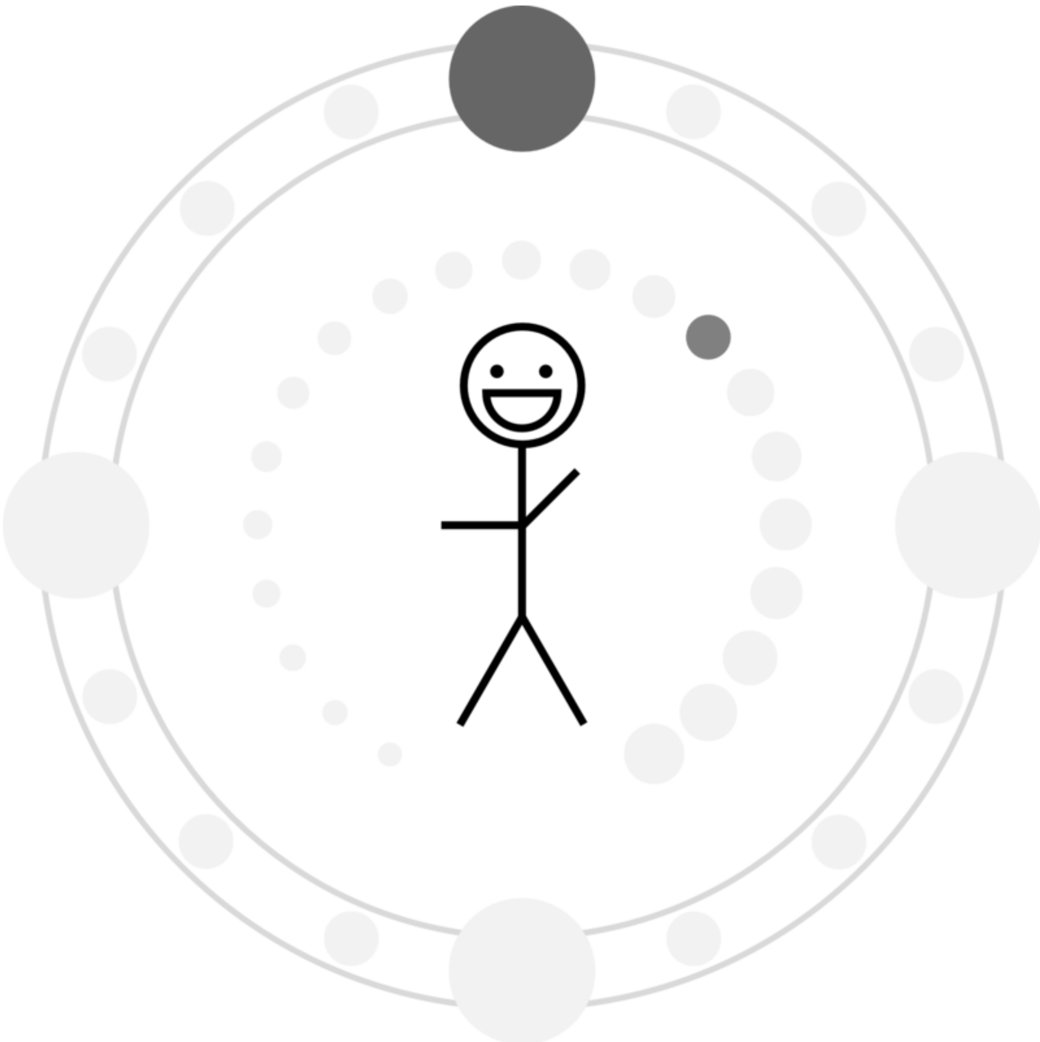


Figure 8.1: Dance move editor prototype

We can clearly see the influence this prototype has from the ideas generated in the participatory design stage. We can decompose it in three areas, from inside to outside: i) the dancer; ii) the musical notes; iii) and the compass.

First, we have the dancer. To make him dance, his arms and legs can be moved, selecting the desired note. In this specific iteration, there are no limits to the movement, but that should be adjusted later to the range of movements a body has and to imitate the way the body behaves. You probably noticed the dancer has a huge smile - this is by no means accidental, as I wanted to express joy and happiness for music and dancing, and what that meant to children, as I discovered in my user research.

Next, we have the musical notes, around the dancer. In this specific picture, we can see the left arm is selecting a specific note. You can notice the notes have no names. This is also on purpose, since there are a lot of children that have not grasped that concept. Instead, the notes different pitches are represented by their difference in size and position. The interaction is simple: the player selects the body part he wishes to move and selects where he wants to move the note. This only represents a movement (in this case, raising an arm), and a dance move is made up of a sequence of movements.

In this stage, I had a diatonic scale (the scale composed by the following notes: C D E F G A B) because I thought that were the sounds the children were most familiar with. However, changed in a later iteration of the prototype because it was not clear enough, as you will see in Evaluation session #1.

To make a sequence of movements, a dance move, we have a quartenary compass, represented by a closed circle. This approach was influenced by Rui Penha's **Gamelan** [Pen12], where a loop is represented by a circle, giving the idea of repetition. The bigger circles represent the quarter notes and the smaller circles are the eight notes. The player simply needs to select what movement he wants to do at a specified beat. Filling all the beats with movements creates a dance move!

This was the part of the prototype that I thought might be difficult to understand by children.

In figure 8.2, a sample of a dance move can be seen.

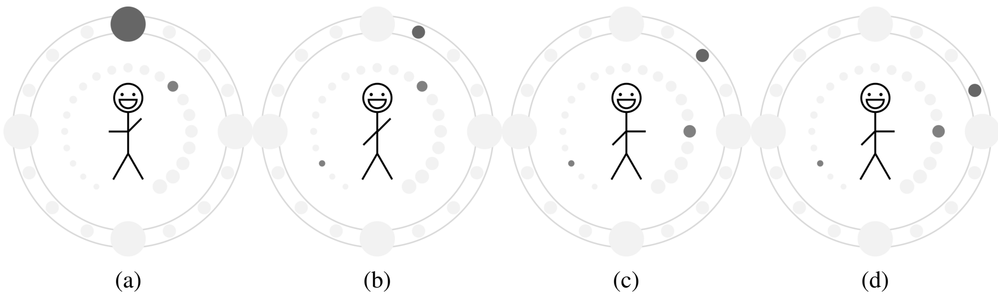


Figure 8.2: Example of a dance move sequence

First, the dancer raises his left arm, then he lowers his right arm, then he lowers his left arm, and then he keeps his position.

This picture only shows a quarter of a dance move. As you can see, there are endless movement possibilities in a dance move (3 111 696, to be more exact). In each beat, we can move each of the four body parts in 21 directions, therefore we have $21\hat{4}$ positions, multiplied by 16 beats we have that number).

As said in the beginning of this section, most of the work will be focused on this specific area of the platform. So, before any prototyping of other areas start, this area was evaluated. This takes us to the next section: Evaluation session #1.

8.2 Evaluation session #1

This section will describe the first evaluation session, and it is composed by three sections: i) introduction; ii) results; and iii) iteration.

8.2.1 Introduction

This session was held in one of the schools I partnered with, with children that were not a part of the design team - therefore, they had no previous knowledge of what I was doing. The kids were third graders, aged eight and nine, and were tested in pairs. The full session script can be seen in the Appendix A, section A.3.1 Evaluation session #1. Here, I evaluated a paper version of the prototype described in the previous section, that can be seen in figure 8.3.

To emulate interaction, I used Kelley's Wizard of Oz technique [Kel84], where I would add, remove and move parts, observing their reaction. This way, children could observe the reactions of the prototype and respond accordingly, as if in a digital device. Figure 8.4 shows the sequence of interactions that was evaluated.

With the first beat selected, we move the right arm and leg. Then, we select the next beat and move the body parts again. Finally, we select the next beat and we move all body parts.

Using this technique I was able to produce a prototype in a matter of hours that could be evaluated. At this point, I was not worried about how the music sounded. It was more important if they grasped the concepts in the prototype.

In the beginning of the session, to give them context, I said what I was doing there and what my project was about. I used a scripted text, so that the results are not influenced by what I said or done. The session was held in the school library, as the teachers said it was a familiar distraction-free environment for the participants.

The goals of this session are:

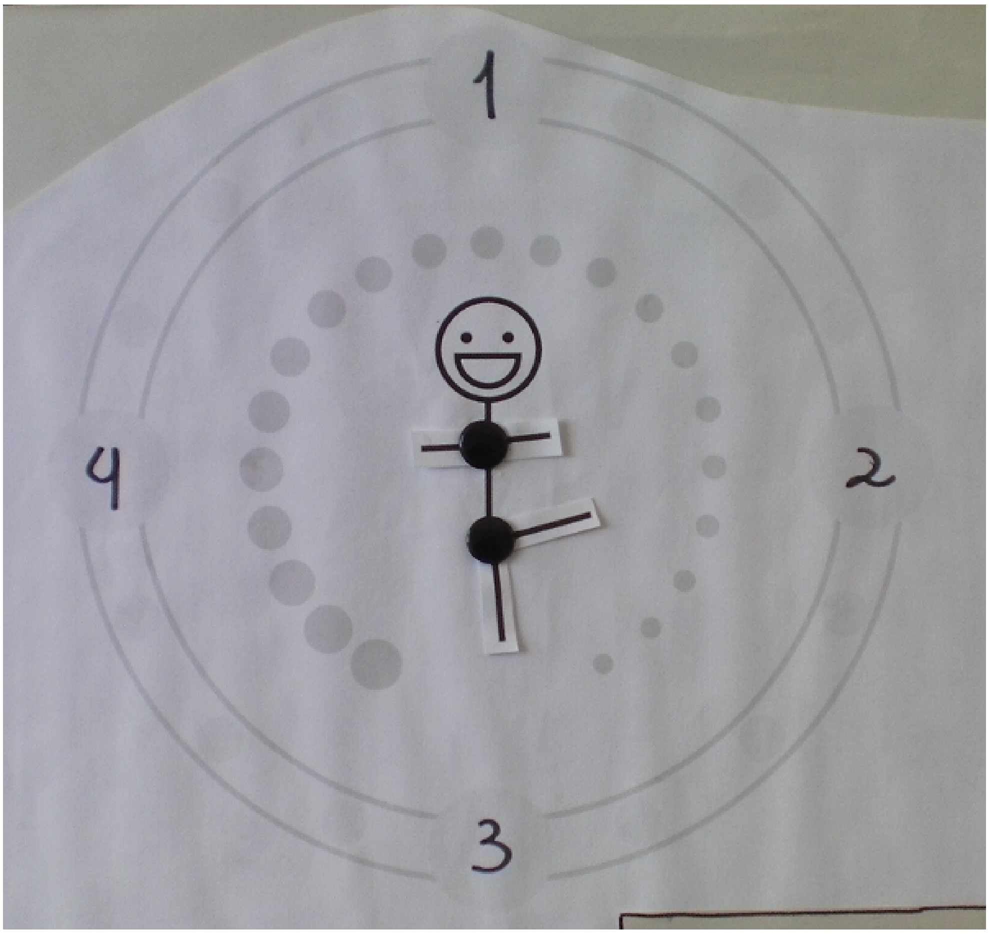


Figure 8.3: Prototype subject to evaluation

1. to see if they can recognize all the elements on the prototype;

2. to see if they are able to create a dance move.

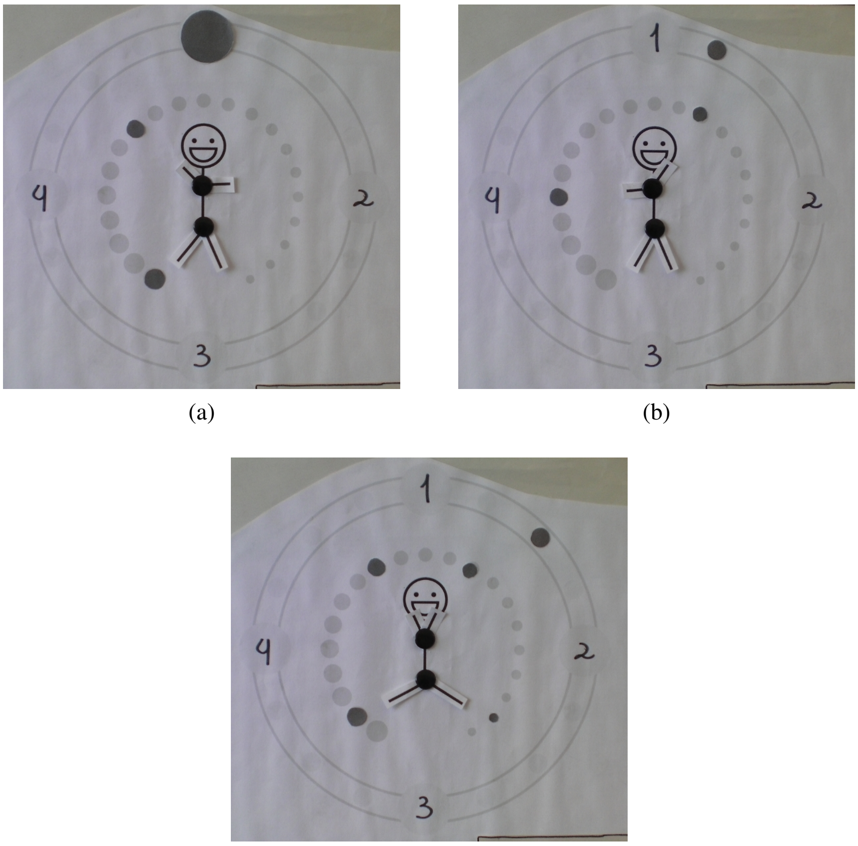
8.2.2 Results

In total, I was able to evaluate four pairs of children. At this point, I decided to stop because all of the groups were struggling on the same issues and I could identify what I needed to change.

All of the participants were able to recognize and manipulate the dancer easily.

However, when asked about what the outer circle was, none of the participants was able to recognize it. Some said it was a stage viewed from above, others said they were stage lights, everything except what they were.

When we moved to the interaction part, some of them touched one of the circles, and I made the appropriate reaction. However, only a small percentage understood that we could make a sequence of movements using that circular apparatus.



(a) (b)

(c)

Figure 8.4: The interaction evaluated on the Evaluation session #1

While executing the tests, I had the feeling that their issues could be related to the lack of reation to their actions provided by the paper prototype, rather than them not understanding what it was at all. To address this issue, I decided I would: i) develop a functional version of the prototype and evaluate it again; ii) and do a very low-fidelity prototype of the **dance stage** area of the prototype, so that they would get the appropriate reactions, maybe improving their knowledge on how to interact with the **dance move editor**.

8.2.3 Iteration

In this iteration, two things were made:

- the existing prototype leaped from paper to digital. Besides the issue with the compass, I wanted to see how they actually created music;

- I prototyped in paper the remaining area: the dance stage, because maybe they did not understand the previous prototype due to lack of context.

Paper to digital

Since I am the only person working on the project, I had to stop the design in order to implement this prototype. Therefore, I wanted to implement it in the minimum possible time, in order to have time to do a couple more iterations to the prototype.

I built this prototype using native technologies to the browser. For the visuals, I used SVG because I am able to import vector graphics made with software (such as Adobe® Illustrator and Inkscape), therefore reducing my time drawing the visual apparel. To simplify the implementation, I used a library called **Raphael** [Bar12]. For the audio, I used the new **HTML5** Audio features [Hic12], because this prototype is the foundation of the actual platform and I challenged myself to do it using only native technologies. To simplify the implementation, I used a library called **Sound Manager 2** [Sch12]. In a matter of two weeks I had a running, fully functional, prototype.

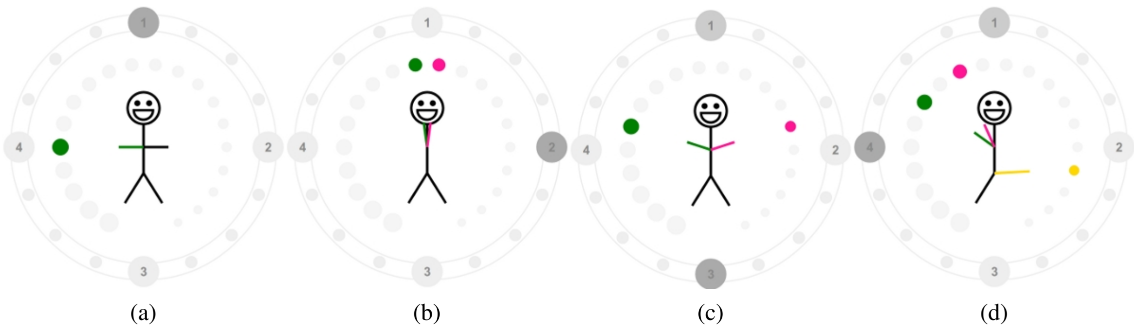


Figure 8.5: Samples of the running prototype

As figure 8.5 shows, there are some small improvements.

First, each body part has its own color, as well as the corresponding selected note. This way, we know what note belongs to what member of the body.

The notes were also changed, in two ways. First, they start big (low) to small (high), the opposite of the previous iteration, so that it corresponds to how we relate the pitch of a note to a size. Second, instead of a diatonic scale, we have a pentatonic scale (composed by the following notes: C D E G A), after recommendation of the music teacher that followed this project.

The interaction is simple: one just clicks on the desired body part and selects the desired note to define the position. When hovering the notes, the selected body part moves around, so the player can see on what position will the part be if he selects that note.

The dance stage

This prototype is low-fidelity and I simply created it to give context to the **dance move editor**. In this iteration, I wanted to keep the interaction to a bare minimum, just enough to allow children to progress to the dance move editor. However, there are some important considerations to make regarding the way one interacts with it.

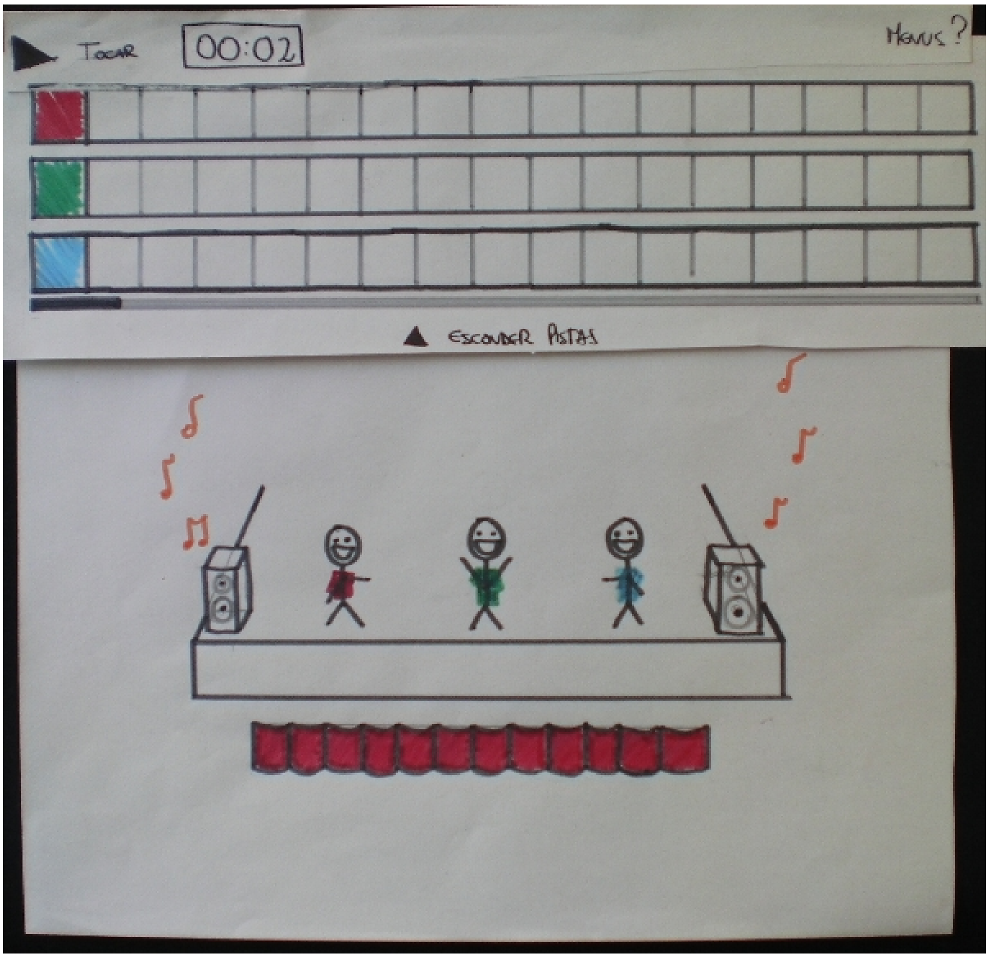


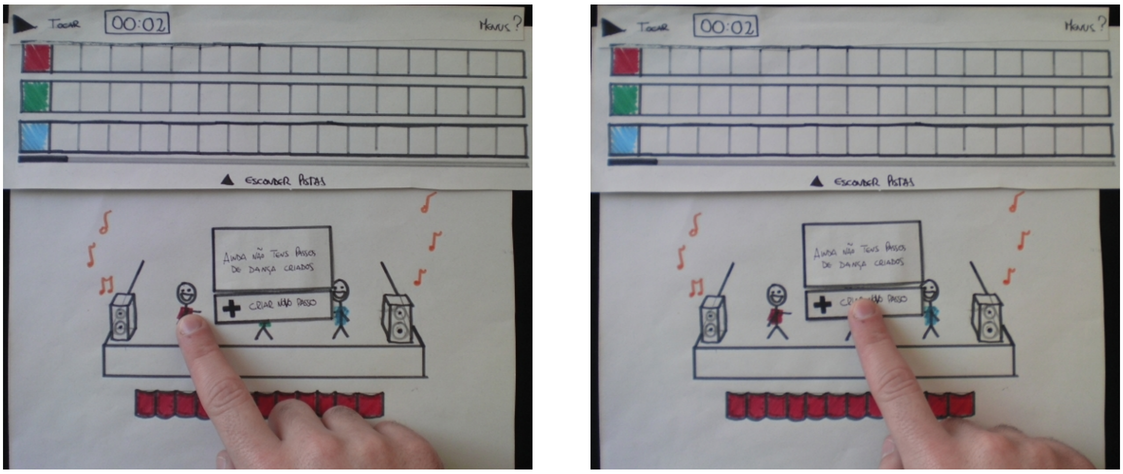
Figure 8.6: Dance stage

In figure 8.6, you can see the prototype has two main areas: i) the dance stage; ii) and the dance tracks. The bottom half is the **dance stage**, where the dancers are. Each dancer has a unique identifier, in this case a colored shirt. The upper half contains **tracks**, one for each dancer, where children will be able to arrange the dance moves into a routine.

The interaction takes place the following way. First, we select the dancer we want. If that dancer does not have any dance moves, he gets an appropriate message and a button saying "Create new dance move". After pressing this button, the dancer goes to the **dance move editor**. This sequence can be seen in figure 8.7.

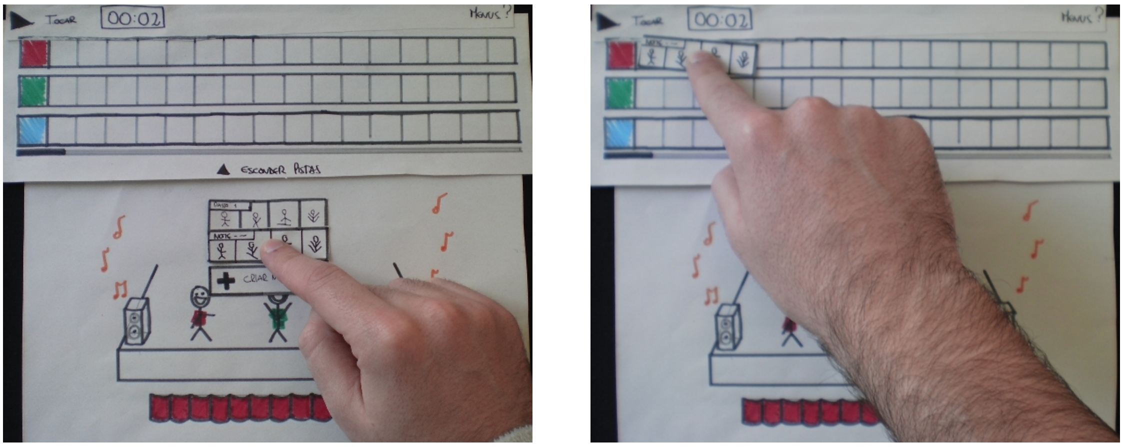
As shown in the figure 8.8, after returning from the dance move editor, with a new dance move created, the list shows the newly created dance step, which he can drag and drop to the track position he wishes (or click, and then click on the track to drop it - this movement needs to be evaluated).

After finishing this prototype, I am ready to evaluate it, and this takes me to the next section.



(a) (b)

Figure 8.7: Interaction with the dance stage, if the player did not create moves



(a) (b)

Figure 8.8: Interaction with the dance stage, if the player created moves

8.3 Evaluation session #2

This section will describe the second evaluation session, and it is composed by three sections: i) introduction; ii) results; and iii) iteration.

8.3.1 Introduction

The structure of this session, as well as its location, is exactly the same as the first session: four pairs were tested in the school library. However, here I will be evaluating the both prototypes, that will cross the platform from start to finish.

Since the **dance move editor** is functional, I was also able to evaluate how they collaborated to create music.

Therefore, this session goal is to make a dance and a move and to assemble it in the routine. This will require them to understand all elements in the game and to collaborate. The full session script and results can be seen in the A.3.2 Evaluation session #2.

8.3.2 Results

This session proved me wrong in many ways.

Using the digital prototype of the dance move editor only translated into a small improvement of how they understood the elements in the game. The dance stage low-fidelity prototype also did not help in giving the necessary context.

First, every participant was able to interact with the dancers in the dance stage correctly. However, when confronted with the "Dance moves" dialog, some of them were confused and unsure of what to do. However, most of them pressed the "Create new dance move" button.

After pressing the button, I would open the laptop lid with the game already loaded. Their first reaction was: "Wow, what is this? Can I play with it?". Most of them immediately tried to interact with the dancer. The first thing that surprised me was that, when hovering a movable body part, they knew it was clickable just by seeing the cursor changing from a pointer to a hand. However, there were some issues on the way they interacted with the dancer: some pressed a body part, and then tried to drag it to the position they wanted to; others clicked on the body part and then moved the mouse around, waiting for the part to follow it. However, when hovering the notes they immediately understood on how to interact with it.

At this point, I asked the question - "How do you think you can move his left arm, and then his right arm, sequentially?". All the participants, without exception, moved the left arm and then the right arm. I followed with - "But I want him to raise his left arm first, and then his right arm". At this point, they got confused. Some tried to raise and lower the arms, in sequence. Others did not do a thing. I pressed the play button, placed on the right side of the canvas, and the compass started moving, making the puppet dance, just as they defined. Despite the amazing reactions this caused, only one group understood how the compass worked, and how to do a dance move correctly.

After that, I closed the laptop lid and came back to the paper prototype. This time, instead of a blank list, they had the dance move they just created. Two groups were able to drag the dance move to the corresponding track. The other two were not able to do this - the first did not understand what the tracks were, claiming it was to keep score; the other was getting frustrated, so I decided to stop the session.

The main problems in the **dance stage** area were:

- difficulties in understanding what the tracks were;
- difficulties on the relation of the dance move and the track;
- difficulties on the transition between the dance stage and the dance move editor.

The problems with the **dance move editor** persisted:

- difficulties in understanding how to do a sequence of movements;
- the interaction with the dancer is not obvious.

The next iteration will attempt to solve these problems.

8.3.3 Iteration

Due to the problems I presented in the previous sections, both prototypes were iterated.

Dance move editor

The biggest problem in this area is the way children interpret the compass representation. Unable to understand it, they are not able to create a sequence of movements, the dance step itself. Instead of a circular representation, I decided to use a linear array of movements:

As figure 8.9 shows, the biggest difference is how the compass is represented. In this version, there are two clear advantages:

1. the linear representation implies continuation, sequence, that helps users form the correct mental model of how a dance move is composed by a sequence of movements;
2. this representation is aligned with the one on the dance stage, therefore establishing a stronger connection between the two areas.

There is also another important aspect, that has to do with how we store information. Specifically, our short-term memory (also known as working memory). On average, human adults can store seven items, plus two minus two, in their short-term memory, for about thirty seconds [MP60]. Recent papers claim that the number of items we can store is even smaller. However, children can even store less: four to five items, for five years old; six items for nine years old. [Dem81].

In the previous prototype, I was showing all the sixteenth notes of a 4/4 compass. While making a movement, we always have all the other movements to take into account , so that the dance move works as a whole. This meant children had to remember sixteen different moves or they had to constantly be playing the whole thing over and over.

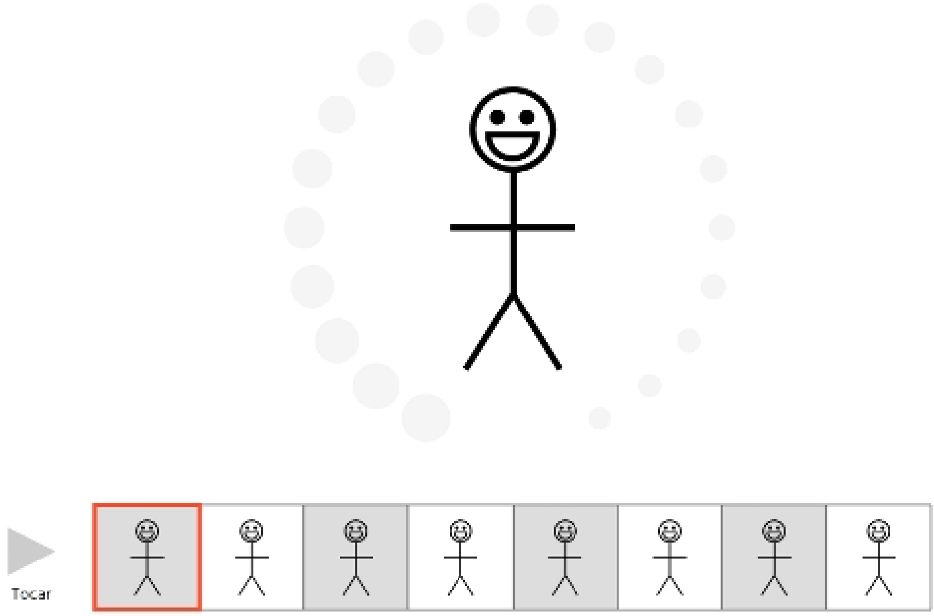


Figure 8.9: Iterated dance move editor

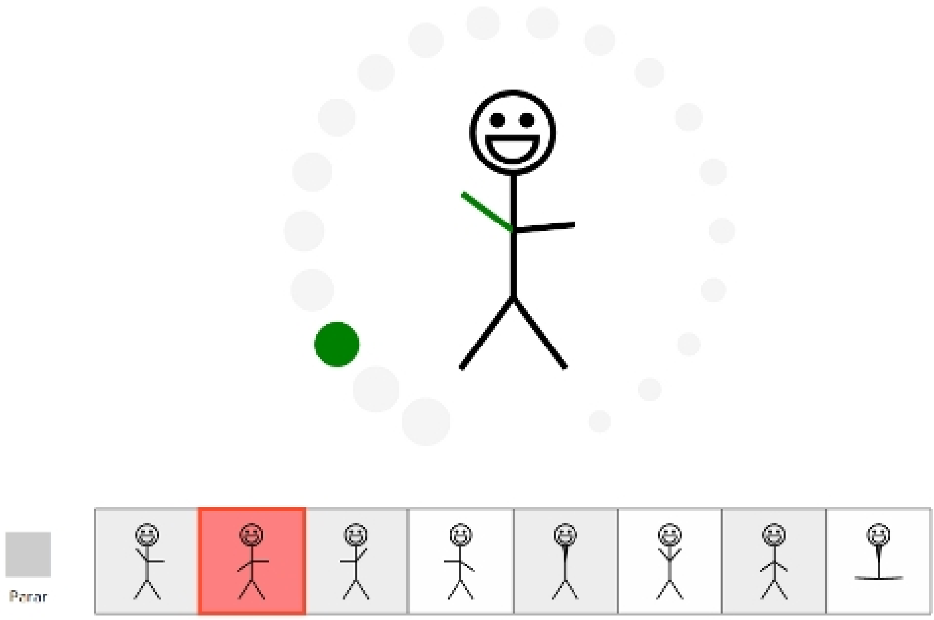


Figure 8.10: Iterated dance move editor - detail of a sequence being played

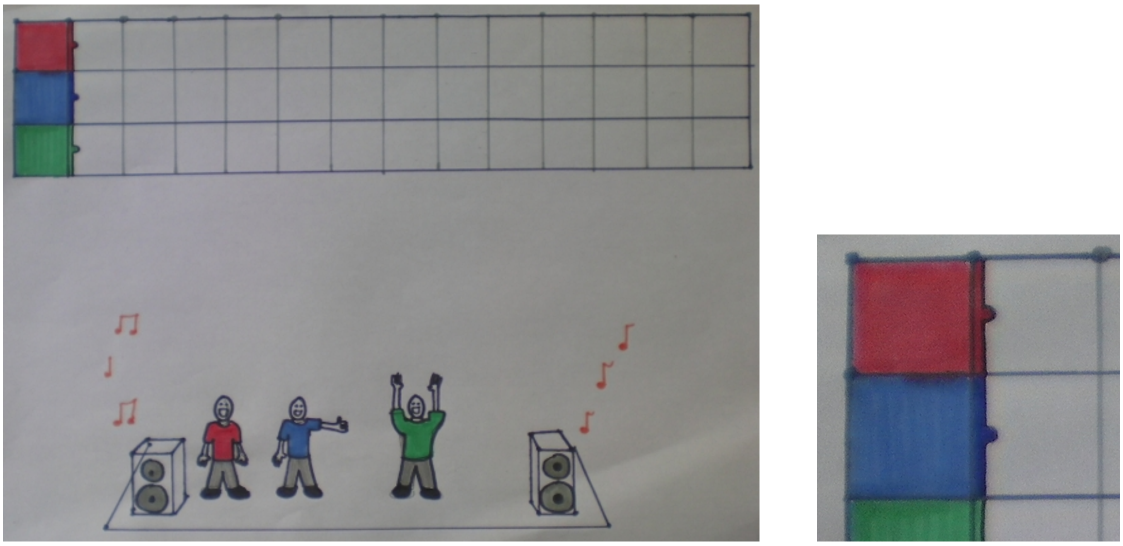
Because of this, I decided to show a preview of the movement in each of the beats of the compass. Figure 8.10 shows an example of a dance move.

This preview also gives cues on how the compass works, as children understand that to make a dance move, they have to make up the individual movements.

I decided to leave the interaction with the dancer as it was, although some of the participants had some trouble in the previous evaluation session. However, after understanding how it worked, they could use it without trouble.

Dance stage

The biggest problem in this area with the dance stage is that children do not understand what the tracks are, and how they relate to the dance moves. To address this problem, I decided to introduce a small change that hopefully can make a big difference and enable me to solve this drawback.



(a) (b)

Figure 8.11: Iterated dance stage

As you can see in figure 8.11, nothing really changed. Except that in the tracks color identifier we have a very small peg sticking out, looking almost as a puzzle piece - as you can see in 8.11b. The goal of a track is to be a place where children arrange the dance moves of a specific dancer to create a routine. To make that sequence of moves, we must fit together the dance moves, as if assembling them.

Therefore, each dance move has a space in the left end and a peg in the right end, so that we can interlock each piece to each other, therefore making the model stronger.

I did another small change to the prototype that aimed to make the relationship between the dance moves and the corresponding tracks.

When children select a dancer, everything except that dancer and its corresponding track are blurred (or any effect that makes those elements blend to focus the attention on the relevant elements). As figure 8.13 shows, I also exaggerated in the size of the dance move on the list, to cue children that element was draggable (in the previous prototype, it blended too well with the other

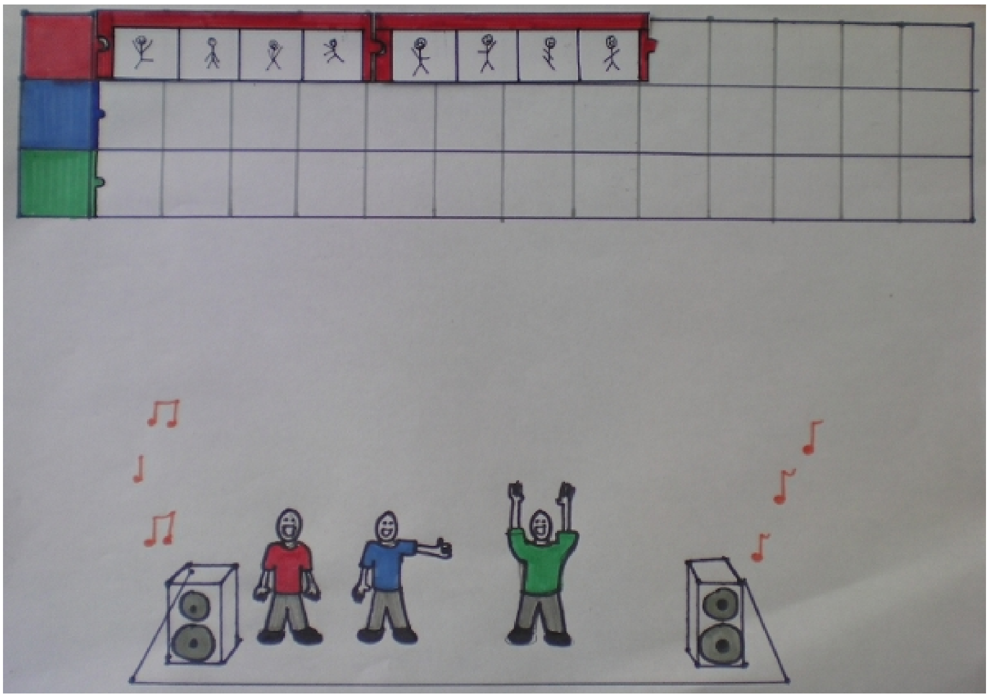


Figure 8.12: Iterated dance move editor

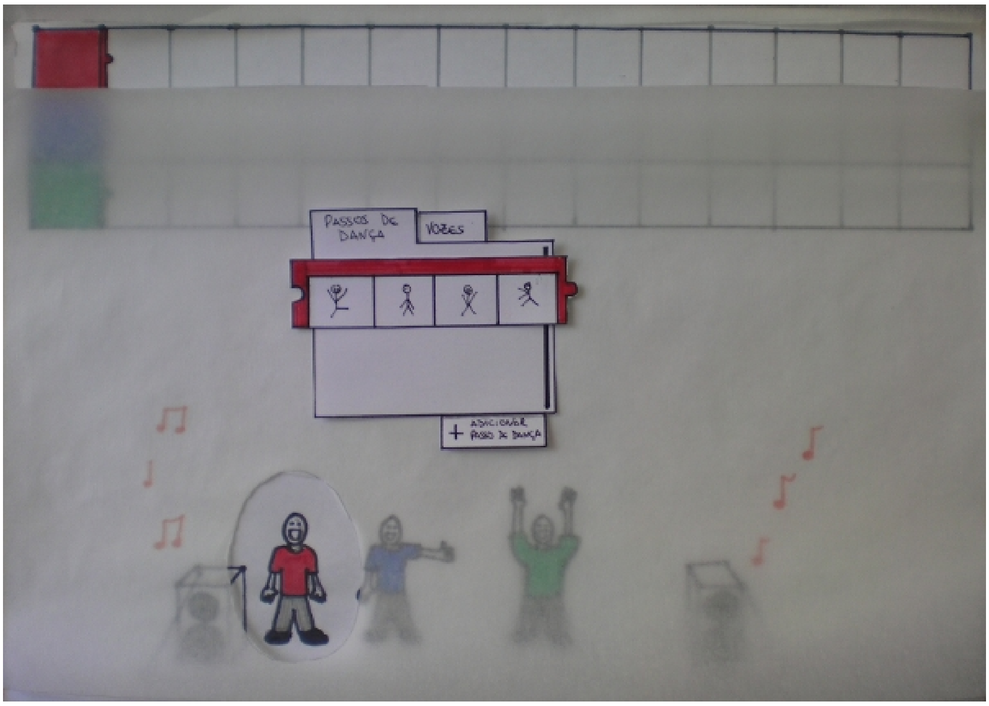


Figure 8.13: Iterated dance move editor

elements, making it appear static).

With the new prototype in hands, I head to the third and final evaluation session.

8.4 Evaluation session #3

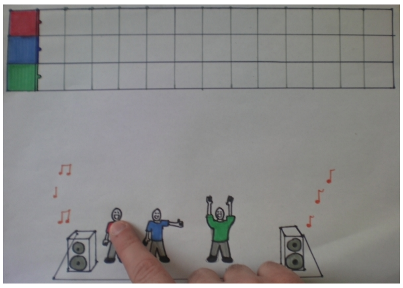
This section will describe the third evaluation session, and it is composed by three sections: i) introduction; ii) results; and iii) iteration.

8.4.1 Introduction

The third and final session has a similar structure as the previous sessions. Four pairs of chilren aged between eight and nine were tested in the school library.

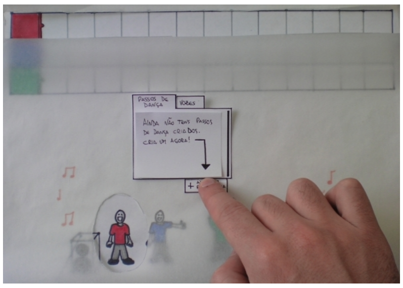
The script used in this session is exactly the same as the previous session , so that I could see if the solutions of the new designed worked. The full session script can be seen in the A.3.3 Evaluation session #3.

The test started with children selecting the red player and them creating a new dance move, as figure 8.14 shows.



(a)

(b)

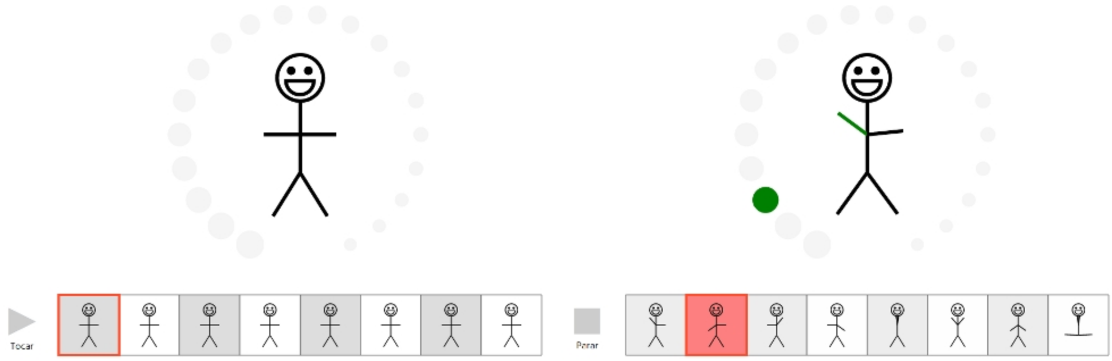


(c)

Figure 8.14: The interaction evaluated on the Evaluation session #3

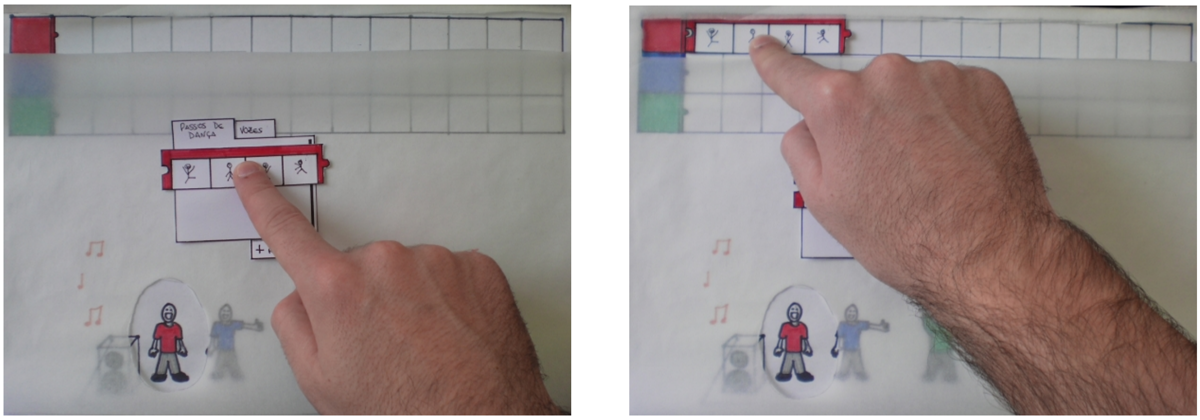
After this, I moved on to the digital prototype, to create the dance move, as figure 8.15.

Finally, I showed the paper prototype again for them to assemble the dance move into the right track, and this way create a dance routine, as figure 8.16 shows.



(a) (b)

Figure 8.15: Continuation of the interaction evaluated on the Evaluation session #3



(a) (b)

Figure 8.16: Continuation of the interaction evaluated on the Evaluation session #3

8.4.2 Results

The best way I can see if my proposed solutions worked is to observe if the difficulties present in the previous session persisted. The problems I encountered in the previous evaluation session were:

- Dance move editor:
  - difficulties in understanding how to do a sequence of movements;
  - the interaction with the dancer is not obvious.
- Dance stage:
  - difficulties in understanding what the tracks were;
  - difficulties on the relationship between the dance move and the track;

– difficulties on the transition between the dance stage and the dance move editor.

Starting with the **dance move editor**, there was a notable improvement in how children understood how they could create a sequence of movements - the dance move. In the end of the session, when asked about what it represented, all of them answered: "it is the dance you want to make" or "it is how we can create different movements"! Regarding the interaction with the dancer, the results are the same as the previous session: some of the groups tried to drag the dancer's body parts, or tried to select the body part and moved the mouse expecting the part to move. However, once they understood how to correctly interact with the puppet, which happened quite fast, they had no trouble.

Moving on to the **dance stage**, the biggest problem was that they did not understand what the tracks were. There were also improvements on this particular problem. In the beginning of the sessions, none of the groups could understand what it was, claiming it was the score, or a keyboard's keys. However, after they saw the dance move, the groups could figure out that they fitted into a track. The appropriate clues, even if not obvious at first, create very strong mental models. When asked what tracks were, in the end of the sessions, they answered "it is the music!". Finally, success!

8.5 Summary

The goal of this chapter was to explain how the low-fidelity prototype of the proposed platform was developed, as well as the result of the application of the used methodology.

There are a lot of details of this platform that have not been addressed. This is because designing and evaluating with children takes a lot of time, a lot more than the limited available time this dissertation has, and these areas are crucial for this dissertation's project. This prototype only addresses the critical parts of the platform, specifically the areas where music is created. This prototype needs to be refined further and only then sent to a team of developers.

One issue that is obvious is that collaboration was not evaluated thoroughly. The collaborative features can only be evaluated when the prototype reaches a more evolved state that allows children to actually collaborate with each other. It was possible to collect data that helps understanding how children collaborate, but more iterations are required to reach a point where the data is trustworthy.

This stage is the third and final of the methodology proposed for this dissertation. The goal of the methodology was to develop a prototype alongside children, in order for it to fit their needs and interests.

The concept and requirements of the platform were validated organically, throughout the participatory design activities. Although children's engagement with the concept of this platform was validated organically, it needs to be evaluated again when the prototype reaches a more evolved state with a larger sample audience.

This concludes the worked proposed by this dissertation. Now that the work is done, it has to be discussed to conclude on what went well and what needs improvement.

Chapter 9

Results and discussion

Chapter 5, Research problem and methodology, stated that this thesis' contributions were:

- The introduction of collaboration in a musical composition tool to create better learning opportunities;
- The generation of a Microworld through the use of Participatory Design's methods;
- The creation of a research framework that serves as foundations for creative projects in similar contexts.

This chapter will discuss the results of this work, in order to see if these contributions were met and to reflect on what went right and what went wrong.

As said in the Design methodology section, the context of this work was rather unique. There was no methodology on the literature that could be applied directly to this project, since every project is different. However, from the work of other people, it was possible to extrapolate guidelines **that resulted in a methodology adapted to this dissertation's context**. One of the key concerns when developing this methodology was the unpredictability of working with children. Therefore, the methodology was created to be flexible enough to allow necessary changes, but rigid enough to guarantee a good outcome. The most important aspect of this methodology is the approach it is built upon: Participatory Design, where the goal is to include the target audience in the design team, contributing directly to the result.

This approach, of including children in the design team, reassured me that the work produced is adapted to their needs and interests. When talking about commercial projects, as the one this dissertation's project took place, using an approach that guarantees a good result and spends the minimum amount of time and money is of extreme importance. I believe this approach is viable for commercial products.

Up until now, this document only talked about the upsides of this approach. However, there were also downsides that affected the result that need to be discussed, not only to help others who might use it, but also to justify some decisions and outcomes. First, using this approach is a very time-consuming process, aggravated by the facts that I conducted this study alone and that working with children is sometimes chaotic. Children have very little time available, allowing only small sessions that require to be done for a longer period of time. What happens is that the quality of the results decreases, due to the short sessions, and the execution time increases. Given that this thesis was developed in a commercial environment, a shorter execution time is preferred. Since this methodology is going to be used in future projects, some aspects need to be reviewed.

The fact that this study was conducted by one person, created some problems.

First, planning the sessions and analysing the results is a time-consuming process, especially if those sessions take place twice a week. During the activities it was also difficult to be the facilitator and the observer. Handling a group of young children is far from easy and a second element would ease the burden. Although all sessions were recorded, some details were missed.

The second problem is the number of activities happening at the same time. As chapter 8 referred, the prototype reached a point where it needed to be implemented so it could be properly evaluated. This meant the design had to stop for a couple of weeks. Besides easing the burden of the designers, having a team of developers working on a functional prototype at the same time the design activities take place also improves the results of the evaluation sessions, since the subject of evaluation is the game itself, not a paper representation.

An interesting by-product of this dissertation is the experience obtained from the participatory design sessions. While experimenting methods, one session particularly showed interesting results. Faced with the problem of children not being engaged in the activities or producing the expected results, **competitiveness was introduced**. By making children compete to solve problems, they get **very** engaged in the activity, producing results with more quality. It would be interesting to pursue this approach further, organizing a study to determine if the results improve, or not.

The result of the execution of this methodology was **198 ideas**, generated by the team(s), **85** of which drawn. Some of these ideas defined the core concept and formed a set of requirements, that resulted in a low-fidelity semi-functional prototype.

Regarding the concept of the platform, it was important that it was aligned with the theories of constructivism, social constructivism and constructionism. As Papert said, for children to learn they must be consciously engaged with what they're learning [PH91]. This requires the creation of a world that children are engaged with that allows them to explore the rules and constraints of a certain subject. Although there are a lot of technologies based on these principles, none used a participatory approach to define that world. **By including children in the design process, the concept of this platform, the world children will explore, meets their interests, engaging them in the exploratory activity**.

Every idea in the prototype was sparked by the ideas generated in the design sessions. This is, in my opinion, the most important result of this dissertation and the success factor of this approach. Unfortunately, there were some ideas that never made it to the prototype because they were not feasible or did not contribute to project's goals. However, all ideas were kept for future reference, since they contain a lot of material that can result in other games.

After discussing the positive and negative aspects, it is clear that there is room for improvement. However, most of the issues could only be identified by experiencing them first hand. The projects that will use this methodology will benefit a lot from the knowledge gathered in this document.

Chapter 10

Conclusions

The goal of this dissertation was to answer the following question: "How can we create an engaging music composition tool that provides an unique learning experience?". To answer this question, a **Participatory Design** approach was used, based on a **custom methodology** adapted to the **requirements** of this work.

The prototype that resulted from this dissertation includes ideas from some **theories of cognitive development**, such as **Papert's Constructionism** and **Vygotsky's Social Constructivism**, and from **Computer Supported Collaborative Learning**.

The result is a **dancing game**, where children can interact with the core concepts of music and compose music, all through a metaphor (or, as Papert calls it, **Microworld**) they know well and **feel naturally engaged with**.

The present chapter, the final of this dissertation, will: i) present the future work; ii) and discuss how this work is going to be disseminated.

10.1 Future work

Throughout this document, there are three key aspects to the success of this platform: i) collaboration; ii) children's engagement; and iii) how it affected the development of their musical intelligence. These aspects were not validated thoroughly due to the development stage of the prototype, as it is still too early to obtain accurate data that shows how both features perform. All require extensive studies that are outside of this dissertation's focus, specially the last one, the development of children's engagement, where a group of children should be tested through a long period of time to observe if there are improvements.

However, the results from the participatory design and evaluation sessions yield good indicators on the first aspects. The way I crafted the collaboration features are based on what I observed in their interactions with each other and with technology. Still, they need to be thouroughly evaluated. Their engagement with the platform was also, as said in the last section of the previous chapter, organically evaluated throughout the design sessions. Still, this study was based on only two schools and results may vary with other schools, so the platform needs to be evaluated with a larger audience.

As the evaluation sessions happened, the prototype was getting more and more detailed. However, it was only possible to go to a certain depth. Although a design specification that guides the rest of the design of this platform has been written, the prototype has to be evaluated often, as new details are designed as implemented.

The prototype also needs to be validated with a teacher's panel. Throughout the process, a teacher already gave positive valuable insights in several aspects. However, when the platform reaches a state where most of the features are implemented, it needs to be evaluated with a panel to discuss if it meets their expectations and the learning goals they defined.

10.2 Dissemination of the work

This section will give a brief description of how this dissertation's work is going to be disseminated in two different ways: i) scientifically; and ii) industrially.

10.2.1 Scientific dissemination

As section 5.2, Design methodology, describes, a methodology that could be used directly in this dissertation's work did not exist. The creation of a methodology was, therefore, necessary.

A long paper describing how this work's process and results was submitted to the Interaction Design and Children 2012 conference, that is going to take place in Bremen, Germany. The goal of this paper is to disseminate the process that was described in this thesis, so that it can be used in similar projects. This paper can be seen in appendix C, Paper submited to the Interaction Design and Children 2012 conference.

To disseminate this work in the music scientific community, a similar paper will be submitted to the New Interfaces for Musical Expression 2012, that is going to take place in Ann Arbor - Michigan.

10.2.2 Industrial dissemination

As chapter 1, Introduction, describes, this dissertation's work belongs to a commercial project called *schoooools.com*. The goal is to integrate this dissertation's result in that project. The methodology developed throughout this dissertation will, hopefully, be used in projects to be developed inside *schoooools.com*.

This work is just a small dent in the boundaries of the research areas it fits in. Together with the contributions that keep popping up every day, we can push those boundaries further. In the beginning of this document, I stated that *music is such a big part of our lives that a world without it is unimaginable*. Despite I believe in this with all my heart, I want to make a small adjustment: *creativity* is such a big part of our lives that a world without it is *uninteresting*. Educational systems all around the world are catching up. However, there is a long road ahead for those who work everyday to elevate the creative disciplines to the level they deserve.

When this happens, if it happens, the world will be a better place, not only because we will experience differently, but because we will mold it differently, in new and infinitely more interesting ways.

References

[Alp84] Philip Alperson. On Musical Improvisation, 1984.

[Arm94] Thomas Armstrong. The Foundations of the Theory of Multiple Intelligences. New York: Basic Books, 1994.

[Art11] Exploding Art. jam2jam: collaborative audio visual performance software, 2011. Available at http://explodingart.com/jam2jam/jam2jam/Home/Home.html, Accessed July 2011.

[Bar12] Dmitry Baranovskiy. Raphaël—javascript library, 2012. Available at http://raphaeljs.com/, Accessed January 12 2012.

[BEK87] Gro Bjerknes, Pelle Ehn, and Morten Kyng. Computers and democracy: A Scandinavian challenge. Alebury, Aldershot, UK, 1987.

[BH98] Hugh Beyer and Karen Holtzblatt. Contextual design: defining customer-centered systems. San Francisco, CA: Morgan Kaufmann, 1998.

[BK08] Maton K. Bennett, S. and L. Kervin. A composer's study of young children's innate musicality. Bulletin of the Council for Research in Music Education, (39):775–786, 2008.

[BK09] N. Bryan-Kinns. Daisyphone, 2009. Available at http://gouda.dcs.qmul.ac.uk/, Accessed July 2011.

[Bro58] Donald Broadbent. Perception and Communication. Elsevier Science Ltd, 1958.

[Car04] John M. Carroll. Beyond fun. Interactions, 11(5):38, September 2004.

[Car11] John M Carroll. Human computer interaction (hci), 2011. Available at http://www.interaction-design.org/encyclopedia/human_computer_interaction_hci.html, Last accessed June 30 2011.

[CC07] Reinmann Rober Cooper, Alan and David Cronin. About Face 3. Wiley, 2007.

[Chi11] One Laptop Per Child. One laptop per child", 2011. Available at http://one.laptop.org/, Accessed July 2011.

[Col10] Tecla Colorida. Escolinhas criativas, 2010. Available at http://info.escolinhas.pt/escolinhas-criativas/, Last modified October 2010.

[dE11] Plano Tecnológico da Educação. Plano tecnológico da educação, 2011. Available at http://www.pte.gov.pt/pte/PT/, Accessed July 2011.

[dEdP11] Instituto Superior de Engenharia do Porto. Instituto Superior de Engenharia do Porto, 2011. Available at http://www.isep.ipp.pt, Accessed June 27 2011.

[Dem81] F. N. Dempster. Memory span: Sources of individual and developmental differences. Psychological Bulletin, (89):63–100, 1981.

[Dix02] Finlay Janet Abowd Gregory D. Beale Russell Dix, Alan. Human-computer interaction. Pearson - Prentice Hall, 2002.

[dM11] Universidade do Minho. Homepage - Universidade do Minho, 2011. Available at http://www.uminho.pt, Accessed June 27 2011.

[dP11] Universidade do Porto. UP - Universidade do Porto, 2011. Available at http://www.up.pt, Accessed June 27 2011.

[Dru94] Allison Druin. Designing educational computer emvironments for children. Conference companion on Human factors in computing systems - CHI '94, pages 403–404, 1994.

[Dru98a] Allison Druin. Chapter 3: Children as Our Technology Design Partners. The Design of Children's Technology. P, (Age 8):1–9, 1998.

[Dru98b] Allison Druin, editor. The design of children's technology. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 1998.

[Dru99] Allison Druin. Cooperative inquiry: developing new technologies for children with children. In Proceedings of the SIGCHI conference on Human factors in computing systems: the CHI is the limit, pages 592–599. ACM, 1999.

[Dru02] Allison Druin. The role of children in the design of new technology. Behaviour & Information Technology, 21(1):1–25, 2002.

[Esc11] Escolinhas. escolinhas.pt :: Plataforma colaborativa e social para o ensino básico, 2011. Available at http://escolinhas.pt/tour, Accessed June 27 2011.

[Fle11] FlexiMusic. Fleximusic kids composer, 2011. Available at http://fleximusic.com/product/fleximusic-kids-composer, Accessed July 2011.

[Gar83] Howard Gardner. Frames of Mind. New York: Basic Books, 1983.

[GDC+04] M.L. Guha, Allison Druin, Gene Chipman, J.A. Fails, Sante Simms, and Allison Farber. Mixing ideas: a new technique for working with young children as design partners. In Proceedings of the 2004 conference on Interaction design and children: building a community, pages 35–42. ACM, 2004.

[GE90] T.L. Good and Brophy J. E. Educational psychology: A realistic approach. White Plains, NY: Longman, 1990.

[Gol61] Richard Franko Goldman. Varèse: Ionisation; density 21.5; intégrales; octandre; hyperprism; poème electronique. instrumentalists, cond. Musical Quarterly, (47):133–134, 1961.

[GR06] Judith Good and Judy Robertson. CARSS: A framework for learner-centred design with children. International Journal of Artificial Intelligence in Education, 16(4):381–413, 2006.

[Har08] R Harper. Being human: Human-computer interaction in the year 2020. Human-Computer Interaction, 2008.

[HH97] W. Huitt and J. Hummel. An introduction to operant (instrumental) conditioning. Educational Psychology Interactive, 1997.

[Hic12] Ian Hickson. Html5, 2012. Available at `http://dev.w3.org/html5/spec/Overview.html#the-audio-element`, Accessed January 12 2012.

[Hou07] Juan Pablo Hourcade. Interaction Design and Children. Foundations and Trends® in Human-Computer Interaction, 1(4):277–392, 2007.

[HV92] Card Carey Gasen Mantei Perlman Strong Hewett, Baecker and Verplank. Acm sigchi curricula for human-computer interaction. In Association for Computing Machinery, Inc., 1992.

[JT01] Kevin Jennings and Brendan Tangney. Drumsteps - a constructionist approach to music learning. 9th Technological Directions in Music Learning Conference, San Antonio, Texas, 2001.

[Kay90] Alan Kay. Addison-Wesley, Reading. New York: Basic Books, 1990.

[Kel84] J. F. Kelley. Exploring technology-mediated learning from a pedagogical perspective. ACM Trans. Inf. Syst.,, pages 26–41, 1984.

[KMH06] SR Kelly, Emanuela Mazzone, and Matthew Horton. Bluebells: a design method for child-centred product development. Proceedings of the 4th, (October):14–18, 2006.

[Kos94] T. D. Koschmann. Toward a Theory of Computer Support for Collaborative Learning, July 1994.

[Kos96] Timothy Koschmann. Paradigm shifts and instructional technology: An introduction. CSCL: Theory and practice of an emerging paradigm, pages 69–197, 1996.

[Lev98] Lili Levinowitz. The importance of music in early childhood. In Music Educators National Conference, 1998.

[Lin11] Harmony Line. Hyperscore at home, 2011. Available at `http://www.hyperscore.com/harmony_line/about_home.php`, Accessed July 2011.

[Lip02] Lasse Lipponen. Exploring foundations for computer-supported collaborative learning. Proceedings of the Conference on Computer Support for Collaborative Learning Foundations for a CSCL Community - CSCL '02, page 72, 2002.

[LM88] P. Barnes S. Guerrini M. Clement P. D'April Levinowitz, L.M. and M.J. Morey. Measuring singing voice development in the elementary general music classroom. Journal of Research in Music Education, pages 35–48, 1988.

[MP60] Galanter E. Miller, GA. and KH. Pribram. Plans and the Structure of Behavior. Holt, Rinehart and Winston, New York, 1960.

[MWW93] Michael Muller, Daniel Wildman, and Ellen White. Equal opportunity: Pd using pictive. ACM, (36):64–65, 1993.

[Nat87] Jean-Jacques Nattiez. Music and Discourse: Toward a Semiology of Music. Princeton, New Jersey: Princeton University Press, 1987.

[ND86] Donald Norman and Stephen Draper. User centered system design: New perspectives on human-computer interaction. Hillsdale, NJ: Lawrence Erlbaum Associates, 1986.

[NF05] Bo Nilsson and Göran Folkestad. Children's practice of computer-based composition. Music Education Research, 7(1):21–37, March 2005.

[OH96] R. Oliver and J Herrington. Exploring technology-mediated learning from a pedagogical perspective. Journal of Interactive Learning Environments, (11):111–126, 1996.

[oT11] Isle of Tune. Isle of tune, 2011. Available at `http://www.isleoftune.com`, Accessed July 2011.

[Pap93] Seymour Papert. Mindstorms: Children, computers, and powerful ideas. Da Capo Press, 1993.

[PD87] I.C. Peery Peery, J.C. and T.W. Draper. Music and Child Development. New York: Springer-Verlag, 1987.

[Pen12] Rui Penha. ruipenha. » gamelan?, 2012. Available at `http://ruipenha.pt/news/gamelan-3/`, Accessed January 12 2012.

[PH91] Seymour Papert and Idit Harel. Constructionism. Ablex Publishing Corporation, 1991.

[PI69] Jean Piaget and Barbel Inhelder. The Psychology of the Child. New York: Basic Books, 1969.

[Pia28] Jean Piaget. The judgement and reasoning in children. London: Routledge and Kegan, 1928.

[Por11] INESC Porto. ..:: Inesc ::.., 2011. Available at `http://www.inesc.pt/files/pages/inesc.php`, Accessed June 27 2011.

[Pre11] Oxford University Press. Definition and pronunciation of engagement | oxford advanced learners dictionary, 2011. Available at `http://www.oxfordadvancedlearnersdictionary.com/dictionary/engagement`, Last accessed June 28 2011.

[Rea05] Janet C. Reader. The ABC of CCI (Child Computer Interaction). Interfaces, pages 8–9, 2005.

[RM06a] Janet C. Read and Stuart MacFarlane. Using the fun toolkit and other survey methods to gather opinions in child computer interaction. Proceeding of the 2006 conference on Interaction design and children - IDC '06, page 81, 2006.

[RM06b] Yvonne Rogers and Henk Muller. A framework for designing sensor-based interactions to promote exploration and reflection in play. International Journal of Human-Computer Studies, (64):1–14, 2006.

[RT95] J. Roschelle and S. Teasley. The construction of shared knowledge in collaborative problem solving. Computer-supported collaborative learning, pages 69–197, 1995.

[San10] Justin Sante. Team composer: Free, collaborative music composition software, 2010. Available at http://www.teamcomposer.com/, Accessed July 2011.

[Sch12] Scott Schiller. Soundmanager 2: Javascript sound for the web, 2012. Available at http://www.schillmania.com/projects/soundmanager2/, Accessed January 12 2012.

[Sib11] Sibelius. Sibelius groovy city, 2011. Available at http://www.sibelius.com/products/groovy/city.html, Accessed July 2011.

[SK06] Gerry Stahl and Timothy Koschmann. Computer-supported collaborative learning: An historical perspective. Cambridge handbook of the learning, 2006, 2006.

[Ski74] B.F. Skinner. About behaviorism. Penguin, London, 1974.

[SMR06] G Sim, S Macfarlane, and J Read. All work and no play: Measuring fun, usability, and learning in software for children. Computers & Education, 46(3):235–248, April 2006.

[SN93] Douglas Schuler and Aki Namioka. Participatory design: principles and practices. Routledge, 1993.

[SRAD97] Michael Scaife, Yvonne Rogers, Frances Aldrich, and Matt Davies. Designing for or designing with? Informant design for interactive learning environments. Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '97, pages 343–350, 1997.

[SSJ^{+}96] Elliot Soloway, Nancy Scala, Shari L. Jackson, Jonathan Klein, Chris Quintana, James Reed, Jeff Spitulnik, Steven J. Stratford, Scott Studer, and Jim Eng. Learning theory in practice: case studies of learner-centered design. Proceedings of the SIGCHI conference on Human factors in computing systems common ground - CHI '96, pages 189–196, 1996.

[Str92] EF Strommen. Constructivism, technology, and the future of classroom learning. Education and Urban Society, 24(4):466–476, 1992.

[Sym11] San Francisco Symphony. Sfs kids - fun with music, 2011. Available at http://www.sfskids.org/, Accessed July 2011.

[TDFK01] G. TaxÉn, Allison Druin, Carina Fast, and Marita Kjellin. KidStory: A technology design partnership with children. Behaviour & Information Technology, 20(2):119–125, 2001.

[Tun11] Toons Tunes. Toons tunes, 2011. Available at http://toonstunes.com/, Accessed July 2011.

[Val11] João Valente. Avaliação da usabilidade e diversão em interfaces web para crianças - caso de estudo escolinhas.pt. Master's thesis, University of Porto, 2011.

[VI11] Colégio Paulo VI. Paulo vi, 2011. Available at http://www.colegiopaulovi.com, Accessed June 27 2011.

[Vyg78] Lev Vygotsky. Mind in Society: Development of Higher Psychological Processes. Harvard University Press, 1978.

[War09] Todd Zaki Warfel. Prototyping: A Practitioner's Guide. Rosenfeld Media, 2009.

[Wat13] John Broadus Watson. Psychology as the behaviourist views it. Psychological Review, pages 158–177, 1913.

[WDG+10] Greg Walsh, Allison Druin, ML Guha, Elizabeth Foss, E. Golub, L. Hatley, E. Bonsignore, and S. Franckel. Layered elaboration: a new technique for co-design with children. In Proceedings of the 28th international conference on Human factors in computing systems, pages 1237–1240. ACM, 2010.

[Web96] B.R. Webb. The role of users in interactive systems design: when computers are theatre, do we want the audience to write the script? Behaviourt. Behaviour and Information Technology, (15):76–83, 1996.

[WF86] G Winograd and F Flores. Understanding computers and cognition. Addison Wesley, New York, 1986.

[ZG03] Louise;Gibson Lorna Zones, Claire; Mciver and Peter Gregor. Experiences obtained from designing with children. Proceedings of the 2003 conference on Interaction design and children, 2003.

[ZPW+10] Yinsheng Zhou, Graham Percival, Xinxi Wang, Ye Wang, and Shengdong Zha. Mogclass: A collaborative system of mobile devices for classroom music education. In Conference on Multimedia, 2010.

Appendix A

Full session scripts and results

This appendix contains the scripts and the results of every activity described in this thesis. It is divided in three sections: Research activities, Design activities and Evaluation sessions - each one representing a stage of the methodology.

A.1 Research activities

A.1.1 Interviews with children

Introduction

This session consists in a set of interviews, with the goal of understanding how children relate to music. The interviews took place in two schools, on the library. Children aged eight and nine were interview in pairs and, in total, there were ten interviews.

Script

Hi. What's your name? What were you guys doing right now?
My name is Ricardo and I asked you to come here because I am doing something really cool for you and your friends. Do you like music? What type of music do you like the most - do you have any favourite bands?
I wanted to know what you think about what I'm working on. I am doing a web-site where you can create music with your friends, and it is so simple that even my grandma can do it! What do you think about it?

I have some questions I can't answer in my work, so I would like you to help me. They are super easy and I bet you won't have any trouble with them. There are not right nor wrong answers, you can say whatever you want, even if it is goofy, as long as its sincere. Okay? Let's move on then!

1. What is music to you?

2. What do you like the most about music?
3. Do you think music has something to do with painting? Why?
4. What do you usually do in music classes?
5. What do you like the most?
6. Does the teacher give you homework?
    - If yes: and what kind of homework does she give you?
7. Do you work in groups in classes? What do you like the most: to work alone or in groups? Why?
8. Outside of classes, are you learning music?
    - If yes: do you play an instrument? Which one?
9. Does anyone from your family play an instrument?
10. Have you ever used the computer to create music? What did you use?
11. What do you do in the computer?
12. Do you visit websites? Which ones?

All done! It was easy, right? You helped me figure a lot of stuff out. Do you have any questions for me?
I just wanted you to do one more thing, and this is a pact between us. I wanted that, at home, you guys made a drawing of what music represents to you.

Come here and give me a high five! You guys rock!

Results

Due to the small sample, these results are biased according to the children that participated in the interviews.
The results are organized in a bullet list because each item represents an insight based on what children said during the interviews:

- Children associate music to: singing, dancing and listening;
- Dancing is their favorite;
- Children also associate music to emotions, such as: fun, cute, joyful, sad, inspiring and captivating;
- They don't associate drawing with making music, as in music there is no "coloring pencil";

- Children like to work in group because it is more fun and they can help each other. However, they do not like some aspects, such as having to a) wait for others to finish; b) accepts the ideas of others;
- Some of the interviewees didn't have an internet access at home or they had limited access to it;
- Most of the websites they visit are for entertaining purposes, such as playing games and watching videos;
- They relate music composition to team work, patience, rhythm and attention;
- Children understand the feelings music causes, and are able to express them through drawings;
- The children more comfortable with music have someone in their family who play a music instrument.

A.1.2 Pictorial expression

Introduction

In this activity, children are asked to draw what music means to them, at home. This way, they can express sincerely what they feel about music, without the pressure of an interview. All children were aged between eight and nine.

Results

These results are the product of an analysis of the drawings:

- All of the drawings were very happy, due to the amount of colors and happy people in them;
- Most of the people portrayed were dancing - some of the drawings had groups of people (their family or friends) dancing;
- There was also a good number of instruments in the drawings, most of them drawed very accurately, that shows children have a good idea of how instruments look like;
- Although instruments are portrayed, the sound is, usually, coming from speakers;
- Children's perception of music is of a big concert with lots of people dancing on stage;
- Children express sound as vibrations coming of the speakers and as random notes.

A.1.3 Interviews with teachers

Introduction

This session consists of an interview with a teachers panel. In this case, the panel was composed of two teachers and the interview was made in a normal classroom. The goal was to learn more about the presence of music in elementary school and the teachers perspective on music education.

Script

My name is Ricardo Gonçalves and I'm doing my master thesis on a music-related tool. I'm doing a website where children will be able to compose music with each other. The goal is to offer a simple, yet flexible tool where they can explore and engage with music.

I have some questions that you my help me with. I wanted to know more about how they interact with music in school, and how do teachers approach it.

1. How is music taught in public schools?
2. In general, what is the goal of music classes in elementary school?
3. Where do children have more trouble?
4. What strategies do you use to fight:
   - the children's lack of contact with music;
   - the parents' lack of interest in music and arts;
   - the school's lack of resources.
5. Does technology have a part in music education?
   - If yes: is it present in classes or just at home?
   - If not: do other classes use technology?
6. What kind of homework do you give to children?
7. What is the role of fun while teaching music concepts?
8. Can you tell me the three most interesting activities you do with children?

Results

The results are organized in a bullet list because each item represents an insight based on what one of the teachers said during the interview:

- Resources (instruments, etcetera) vary between schools;

- Although teachers follow a set of guidelines, the goals and methods used are different;
- These teachers, specifically, want to create good listeners. They present music relating it with children's personal interests;
- Teachers have difficulties on how to approach composition;
- In their opinion, the introduction of music in school brought creativity and freedom;
- Due to the short duration of music classes, they don't have much time to use technological tools;
- Introducing new technological tools is hard because teachers need to spend time walking children through it.

A.1.4 Technology immersion

Introduction

This activity consists in the observation of children using technology in groups. The goal is to understand how children interact with technology and with each other. The session was done in the school library and each group had three classmates aged eight and nine. Eight groups were observed.

Script

Hi! Today I brought you something different. Can you guess what it is? Your names are?
Today we are going to play a game where you can create rhythms. To make rhythms, instead of using instruments, we have to use steps and ladders. To make sounds, we just place steps and ladders in the board and we drop balls on top of them. When the balls hit something, they make sounds. Let me show you how to play it.

The goal is to create a music in thirty minutes, together. I want everyone to help in the creation of the music, as if you were a team. You can ask me for help if you have any difficulty.

(after the interview)

1. What did you like the best?
2. What did you like the least?
3. How was it to work with your classmates?

Results

These results are based on observations wrote down during the sessions:

- In all the groups have a leader, someone who takes control of the game immediately;
- In some cases, this leader wanted to do everything by himself, ignoring the ideas others gave;
- Children get bored easily waiting for others;
- Their competitive nature made them compete with each other to see who made the biggest number of sounds;
- They understood the game immediately, moving on to the more complex features of the game in a matter of minutes;
- The little animations the game provides cause amazement;
- None of the groups asked for help regarding the interface - they just hovered their mouse at something and, if it was clickable, they tried it;
- Children learned a lot while watching others play;
- Watching others play also sparked new ideas on how to do things;
- Some of the participants have small hands, and they can't manipulate a normal mouse correctly - however, they are able to use the trackpad without problems;
- Despite being able to use the trackpad correctly, sometimes they had problems clicking in the right place;
- While some were very enthusiastic and had the initiative to control the game, some were shy and, when asked, did not want to play;
- There were some cases where children were so excited by the music they were creating, they started dancing.

A.2 Design activities

A.2.1 Creating the instrument of the future

Introduction

This activity is a participatory design session, where children have to create the instrument of the future. The team is composed by an adult designer and five children aged between eight and nine, half males and the other half females. Children give ideas of how they imagine the instruments, and draw them using simple materials, such as paper and coloring pencils.

Script

Hi! You might remember me from the past weeks, but maybe you don't know what I'm doing here. My name is Ricardo and I'm a part of schoooools.com. Besides making that awesome site you use every day, we also like to make games. As I said in the previous sessions, I am working on something related to music. If you remember correctly, I want to create a game were you make music with your friends on the Internet! However, this time we need some help. We decided to work with a group of children - but not any children, we wanted the best. After debating with the schoooools.com team, we decided to choose you for the team: are you up to the challenge?
In the next month, I am coming once a week to meet with you guys. We are going to do several activities, that I am going to explain when the time comes. What I can tell you now is that they will be really fun, and I promise you will not ever be bored.

I am officially inviting you to the schoooools.com Secret Agency. This agency is top secret and no one, except us, can know it exists. Now that you are in the secret agency, you have to choose names. I will give you two minutes to think about it and then you can tell me. We also have a secret handshake, that we use to identify other agents. Never ever use this handshake with other people, the agency can't be compromised.

Today, we are going to create the instrument of the future! Everyone will give ideas and draw them, so that we can discuss how the instrument of the future will be. The goal is to draw the biggest amount of instruments. The rules are: everyone's ideas are equal, even mine; we do not critique others' ideas; what matters is the final result.

Questions to ask during the activity:

1. How would the instrument be shaped?
2. How could we interact with it?
3. What sound does he make?
4. And what if you could have that instrument in the computer?

Results

This session resulted in a big number of drawings, that I used as a base for sketching the first prototype. Some of those drawings are:

A.2.2 "You should be able to..."

Introduction

The second participatory design session has a very similar structure as the first. However, the goal of the activity is to generate ideas for what one should be able to do in the platform. It is a variation of a brainstorm, where the only difference is that all ideas have to start with "You should be able to". After the brainstorm, the best ideas are chosen by the team and prototyped. The teams are the same as the previous session.

Script

Hi! Do you remember what we did last week? What we did is called generating ideas and prototyping. When we want to do something, we have to figure out how it will be. For that, we have to think some ideas and to prototype them to see if they work. That's exactly what we did when we had ideas about the instrument of the future.
Today, we are going to do something different. I am going to talk to you about the details of the work I am doing for schoooools.com and you will tell me what we should be able to do.

As you recall from last week, I am doing a game where you and your friends can create music together. This game will be inside schoooools.com and you can play it just like any game there, or in other websites. Despite you can make music with your friends, you can also play alone. If you decide to play with your friends, each one can be at home playing over the internet, you don't need to be together.

Now that you understand more about what I am doing, I am going to explain the game. Basically, I want you to tell me what you should be able to do in this game I just described. All your ideas have to start with "You should be able to...". Afterwards, we are going to draw, just like last week, the ideas you like the most. This way I can understand how to make a better game for you guys. Let us start!

Results

The result was a big list of ideas. From those ideas, the best (voted by the teams) were: (You should be able to)

- Dance;
- Talk with each other;
- Play alone or in a team;
- Sing songs in the computer;
- Tell others if we like what they did, or not;
- Play the drums' cymbals, while other plays the snare;
- Sing while other dances;
- Connect all the instruments together to produce different sounds;

- See who is playing;
- Have a music theatre;
- Have information of music-related things;
- Create a band to play on a stage;
- Create our own player.

Some of these ideas were drawn:

A.2.3 How would you do that?

Introduction

This is the third participatory design session, the first after having a concept for the platform. Here, the goal is to go to the details of the platform. To do this, children interact with a low-fidelity prototype the way they want to. Then, some questions regarding possible features will be asked to understand how they would do that. Their ideas will be drawn again.
The teams used in this session are the same as the previous.

Script

Today I bring you something new. Actually, it was based on things you said last week.
Some of the ideas we talked about ware about people singing and dancing in a theatre. So, based on that, I have an idea for a game: what if we could have a stage where people dance to music. However, that music is made by the people dancing! Look at this (show them the prototype) - to make people dance we just have to move their arms and legs. What do you think?

Now, I am going to let you play with the prototype, while asking questions:

1. You go to your computer, and this shows up. What would you do?
2. How can you make the person dance?
3. How do you know your friends are playing?
4. How do you know what your friends are doing?
5. How do you make the person sing?

Results

The results of this session were a set of drawings that fed the prototype directly. Some of which are:

A.2.4 "I don't want to be a dummy!"

Introduction

This session is the fourth and final of the participatory design sessions. The goal here is to solve specific problems present in the prototype. However, instead of having everyone contributing with ideas, the team is divided into two, competing to solve the problems I present. Each problem represents one point and the team with the least points are "Dummies".
The teams used in this session are the same as the previous.

Script

Today we are going to do something different. Remember the prototype I brought last week? Well, I am having some problems and I want you to help me solve them.
However, instead of doing what we usually do, this time I want you to play a game. I am going to divide you into two teams and you will be competing against each other. I then present a problem each team has to solve. You are going to discuss between yourselves the best way to solve it, drawing the best idea. In the end, one of you will present that idea to everyone. Then, the team with the best solution will win one point. In the end, the worst team will be dummies! Are you up to the challenge?

Problems:

1. I have this dancer, with musical notes around him. To play this note with his left arm, what would you do? However, I want him to do several movements in a row - like a dance move. How would you do that?
2. Now that you imagined a dance move, I want to know I would make a music with several dance moves. How would you do that?

Results

The results of this session were a set of drawings that were possible solutions to the problems I presented. They fed the prototype directly. Some of which are:

A.3 Evaluation sessions

A.3.1 Evaluation session #1

Introduction

This session meant to evaluate a low-fidelity non-function paper prototype to see if children understood the concepts in that prototype. Four pairs of children aged between eight and nine years old were evaluted.

Script

Hi! My name is Ricardo and I am here because I need your help with something. What is are your names?
I am making a game where you and your friends can create dance steps! You will have a group of dancers on stage dancing and you are the one who is controlling them. However, the way you make them dance is special, and that is why I am here today. To make the dances, you have to make music.
I am going to show you a version of the game made from paper because I am not allowed to show you the computer version yet. However, I want you to imagine as if you were interacting with a computer, OK?

Let us start then! [an explanation of the prototype was given]

1. What do you think that [pointing at the prototype] is?
2. How do you make the person dance?
3. What are these things around the puppet?
4. And these things around the canvas?
5. How do you make several dance steps?
6. How do you see the other dance steps you made?

Results

This session exposed deep problems in the interaction with the prototype. The main problems were:

- Children weren't able to understand the compass;
- The interaction with the dancer was not obvious.

A.3.2 Evaluation session #2

Introduction

This session evaluated the prototype that resulted from the design sessions. The participants were children that never had contact with the prototype, therefore the teams used in the design sessions weren't eligible. All children were aged between eight and nine years old.

Script

Hi! What were you doing right now? What are your names? I asked you to come here because I need some help. I am doing a game for schoooools.com and I wanted you to test it, so that I can improve it. I am going to show you the game and make you some questions. You can answer all you want, there is no right or wrong. I am asking you for help because I forgot how it was like when I was a kid.

What I made was a game where you can make dancers dance, that you can play with your friends! However, instead of dancing to songs made by others, you have to create your own songs! You will understand in just a minute.
I am not going to show you the final version of the game because it is still being developed. However, I brought you some prototypes made in paper. When you see them, I want you to try to imagine as if they were on the computer: you can interact with them with a mouse or a keyboard.

Before we start, I have some questions:

1. How old are you?
2. Do you have a computer at home? Do you use it?
3. Do you have Internet at home? Do you use it?
4. Do you play any music instrument?

(Show them the first part of the paper prototype)
Can you tell me what you are seeing? What is that up there? I want to make the red person dance, how would you do that?

(Show them the virtual prototype)
What do you think you can do here? How would you make the person dance? I want to raise the person's arm, how would you do that? And the leg? Now I want to raise and lower his arm, like as if he was waving, how would you do that? Now I want to make a complete dance.
What is going to happen if I click here? And here? Is there any difference? And what is this around the person?

(Show the second part of the paper prototype)
You can see that there is a difference over there, can you tell me what happened? Now I want to create an entire dance. How would you do that?

That is it, you have finished! It was easy, right? I just have some quick questions. I am going to show you several faces, from very sad to very happy. When I ask you the questions, I want you to point at the face you feel like:

1. Was it easy to make the dance steps?
2. Would you like to play with your friends?

Thank you so much, you helped me a lot!

Results

To analyse the results, the observed data was compiled in a table. The first five rows represent the questions made in the beginning of the session. The final two rows are the questions made in the end of the session and were answered individually. The remaining rows are the parameters defined by the author according to what was evaluated. The classification scheme ranges from 1 (poor) to 5 (great).

A.3.3 Evaluation session #3

Introduction

The goal of this session is to evaluate if the problems found in the previous session were solved. The structure is exactly the same as the last one, since I wanted to ask the same questions to see if I got different (the right) answers. The only thing that changed was the test participants, so that the results were not influenced by their experience with the platform. Since the script is the same, I am going to skip to the results.

Results

To analyse the results, the observed data was compiled in a table. The first five rows represent the questions made in the beginning of the session. The final two rows are the questions made in the end of the session. The remaining rows are the parameters defined by the author according to what was evaluated. The classification scheme ranges from 1 (poor) to 5 (great).

	Group #1	Group #2	Group #3	Group #4
Age	8 and 9	8 and 9	8 and 9	8 and 9
Gender	Both males	Both males	Both males	Male and female
Has computer at home	Both do	Both do	Both do	One has
Has internet at home	Both do	One has	Both do not	One has
Plays a musical instrument	One plays	Both do not	Both do not	Both do not
General comprehension	4	5	4	4
Dance zone comprehension	5	5	5	5
Loop zone comprehension	2	1	1	1
Interaction with the dancers	4	3	3	4
Interaction with the loop zone	4	-	1	2
Loop editor comprehension	3	4	4	4
Interaction with the dancer in the loop editor	4	5	5	4
Compass comprehension	3	2	2	3
Collaboration to create music	5	3	4	-
Notes zone in the loop editor comprehension	5	-	4	-
Loop zone in the loop editor comprehension	4	-	1	2
How easy was it to make a dance step?	3 and 4	5 and 5	4 and 5	2 and 3
Do they want to play with friends?	5 and 5	5 and 1	5 and 5	5 and 5

Table A.1: Results of the second evaluation session

	Group #1	Group #2	Group #3	Group #4
Age	8 and 9	8 and 8	7 and 8	8 and 8
Gender	Male and female	Both males	Male and female	Male and female
Has computer at home	Both do	Both do	Both do	Both do
Has internet at home	Both do	Both do	Both not	Both do
Plays a musical instrument	Both do not	One plays	Both do not	Both do not
General comprehension	4	5	4	4
Dance zone comprehension	5	5	5	5
Loop zone comprehension	2	4	1	1
Interaction with the dancers	3	2	2	2
Interaction with the loop zone	4	3	3	2
Loop editor comprehension	4	4	3	4
Interaction with the dancer in the loop editor	4	2	3	3
Compass comprehension	4	5	4	3
Collaboration to create music	4	4	3	2
Notes zone in the loop editor comprehension	5	4	4	4
Loop zone in the loop editor comprehension	5	5	5	4
How easy was it to make a dance step?	5 and 5	5 and 5	3 and 4	-
Do they want to play with friends?	5 and 5	5 and 5	5 and 5	-

Table A.2: Results of the third evaluation session

Full session scripts and results

Appendix B

Personas

This appendix contains the description of the Personas that resulted of the first stage of the methodology employed in this dissertation. There are four Personas: three students and one teacher.

B.1 Student #1: Bernardo Sousa

Age: Eight years old;
Grade: Third;
Place of Residence: Lavra;
Interests: Music, science and playing video-games;

Goals:

- Wished music was as easy as drawing with crayons;
- Wants to have a band with his family when he grows up.

Bernardo is an eight years old third grader with a big passion for music! His uncle is teaching him how to play the guitar because he wants to have a band with his family when he grows up. Besides playing the guitar, he listens to music a lot, mainly pop music, and he loves to sing and dance to them, making clear his passion for music.
Last year he created his first song. He even created a dance routine for his friends at school to perform while he plays. He says that you need patience and rhythm to make music, and that everyone has to be alert so that they do not miss the beat.
Besides music, Bernardo also plays video-games in his computer and to visit websites. His favourites are Facebook, where he talks with his family, and Youtube - his parents are always checking on him when he does this.
His favourite thing at school is group work, because it is way more fun than doing things alone and he is able to do things faster with the help of this classmates. Since he is extroverted, he usually assumes leadership in these group works, however he always listens to others' ideas.

B.2 Student #2: Maria Carvalho

Age: Eight years old;
Grade: Third;
Place of Residence: Lavra;
Interests: Soccer and painting;

Goals:

- Wants to be a soccer player;
- Also loves painting and art-related things;

Maria is an eight years old third grader. She plays soccer in an official soccer club and it is her favourite thing in the world.
Last year at her school's Christmas party, her class danced a Shakira song. She had so much fun she cannot stop dancing when she listens to music. However, her family does not listen to music at home often, nor anyone plays an instrument. For her, music is an inspiration to dance, sing and move - she loves to move, a lot.
Maria's laptop stopped working a couple of weeks ago, and she has not touched a computer since then. Usually, she plays video-games on her computer, or her brother's. However, she gets bored quickly and often prefers to play outside with her friends.
In her class, besides being known as the best soccer player, she is also know for painting. She usually shares her paintings with her teachers and friends. Her teacher says she is going to be a painter when she grows up!
Last week, the teacher divided the class in groups to do a big project. Since she is a little bit insecure, she takes a step back and lets others take control of the situation - however, she tries to give her ideas. She likes it this way because this gives her opportunity to talk with her classmates.

B.3 Student #3: Rui António

Age: Nine years old;
Grade: Third;
Place of Residence: Avintes;
Interests: Soccer and cars video-games;

Goals:

- Wishes school was as interesting as the video-games he plays in his computer;

Rui is a nine years old third grader. Last year he flunked because he finds school uninteresting. Although Rui is very distracted in class, when he is playing with the computer he gets so engaged he stops listening to whatever is happening around him. Last week, the teacher divided the class

in groups to do an assignment in the computer and he got so focused in his ideas he ended up ignoring everyone else - he even ended up diverging from the initial task the teacher gave. The teacher asked him why he did not listen to others, and he said others hold him back.
When he is at home, he usually plays video-games on his dad's computer. He loved to play games in the internet, but he does not have a connection at home. Since he has small hands, he prefers to use the laptop's trackpad, rather than the mouse his dad uses.

B.4 Teacher: Manuela Araújo

Age: Thirty years old;
Job: Elementary teacher;
Place of Residence: Lavra;
Interests: Creativity and music;

Goals:

- Wants to stay in the same school and to follow the same class from first to fourth grade;
- Wants her students to have more contact with music;
- Would like to use technological tools to help her improve her classes;
- Wishes the school invested more in resources that support the creative subjects.

Manuela is a twenty-nine years old music teacher that is currently teaching several grades in an elementary school. As most teachers in Portugal that teach extra-curricular classes, she is on an one-year contract. After the contract ends, the end of the school year, she has to fight for her place at this school, or any other school, in a public contest, causing a big uncertainty in her life. Whenever she has to change school, she does not know in what level children will be, because there is no mandatory music curriculum. Besides that, the resources are different in each school, so she does not know what she has to work with. Despite all these difficulties, her goal is to train good listeners, so that children can enjoy music and culture when they grow up.
Since most of her students only has contact with music at her classes, they do not have a developed music intelligence. To engage them in music, so that they are able to develop that intelligence on their own, she tries to relate music with children's interests. All the activities she does in classes are fun and engaging, so that children get motivated to learn more about music.
Although there are many digital music-related tools, she continues to use the traditional methods because she would lose too much time teaching children how to use those tools, since most of them are complex. Besides, half of the class has their personal laptop broken or with problems, and the school's computer room is being used for normal classes. Still, she tries to show some digital content from her computer in the interactive board, to make some more complex concepts easier to teach.
Manuela admits she has some difficulties introducing music composition in the classroom, since

its such a complex concept. She says it is difficult to elaborate activities that make it easier to teach music composition.

Appendix C

Paper submited to the Interaction Design and Children 2012 conference

Dancelidoo: A Learning Music Composition Tool For Children Based On A Microworld Designed By Children

Ricardo Gonçalves
Faculdade de Engenharia da Universidade do Porto
Rua Dr. Roberto Frias, s/n
4200-465
Porto, Portugal
ricardo.goncalves@fe.up.pt

Paula Silva
Faculdade de Engenharia da Universidade do Porto
Rua Dr. Roberto Frias, s/n
4200-465
Porto, Portugal
palexa@gmail.com

Rui Melo
Escola Básica Adriano Correia de Oliveira
Rua Castanheira de Ribatejo
4430-784
Avintes, Portugal
ruimelo@netcabo.pt

Ademar Aguiar
Faculdade de Engenharia da Universidade do Porto
Rua Dr. Roberto Frias, s/n
4200-465
Porto, Portugal
ademar.aguiar@fe.up.pt

ABSTRACT

Children are very creative beings who express that creativity in many ways naturally. One of those ways is through music, where it has been proven that they are capable of composing with form and structure without any formal education. However, we keep trying to develop their musical intelligence using that formal music education, in ways that aren't natural for them. Papert's microworld concept has been the foundation of several examples in educational software, based on the fact that it helps children grasp complex concepts by letting them explore a world defined by the rules and constraints of a certain domain. To engage with such microworlds, children must be naturally interested in the environment that forms that world. This paper will show how its possible to use Participatory Design's methods to explore music-related microworlds that allow children to engage in exploratory activities.

Keywords

Child-Computer Interaction, Children, Participatory Design, Microworld

1. INTRODUCTION

The development of a musical intelligence at an early age is as important as the development of other types of intelligence, such as logical-mathematical and linguistic [4] [1] [10] [6] [5]. However, we keep trying to develop children's musical intelligence using formal structures, in ways that are not natural to them [9]. This creates a gap between children and music, where that natural creative feeling is overpowered by the unnatural learning of the complex concepts behind music. Despite all this, children are able to create music with form and structure without any formal education [8], the same way they do not need a degree in Painting to know how to draw a picture.

One of the approaches that is used in educational technology is based on Papert's constructionism. A relevant concept for this type of technology is the **microworld** concept. A microworld is an environment defined by the rules and constraints of a certain domain [9]. This environment allows exploration and experimentation on that domain, as a way to learn its concepts. However, Papert states that for learning to occur, one must be consciously engaged with the activity one is performing [9]. How can we create a microworld that children feel engaged with, so that they engage in learning activities?

This paper will present a study whose aim was to create a tool that allows children to engage in exploratory activities in music.

2. INVOLVING CHILDREN IN THE DESIGN PROCESS

When creating new technologies for children, one cannot assume children are just short adults [3]. Also, one cannot rely solely in his own experience, nor in teachers and parents. To know more about children, one must interact with children directly [3]. Allison Druin stated that there are four roles children can play in the design process of a new technology: i) user; ii) tester; iii) informant; iv) and design partner:

1. As **users**, children are observed using a piece of technology, usually a product in the market, so that the impact that technology can be understood. The rela-

tionship between the design team and children is indirect, as there is no direct interaction between the two parts;

2. As **testers**, children are also observed using a piece of technology, although that technology can be in a developmental stage. Here, the goal is to obtain feedback about the product so that the team can improve it before it comes out to public;
3. As **informants**, children not only give feedback about a certain technology, but also give input regarding their experiences in a certain domain. This input can be given before the product's development process starts;
4. Finally, as **design partners**, children are part of the design team, contributing directly to the design of the technology. In this role, children are considered equal stakeholders due to their unique perspective and input.

The last role, **design partners**, is based on Human-Computer Interaction's approach Participatory Design, where "the goal is to provide an equal opportunity design envi- ronment in which all participants can contribute as peer co-designers" [7]. Although Participatory Design offers a lot of methods and techniques, they are most effective with adults [11], and they need to be adapter to children [2].

To understand what children need and want, one must work closely with them. To create a tool that engages children in learning activities, the concepts inside that tool need to be perfectly aligned with their needs and interests.

Coming back to the microworld concept, one needs to be engaged with the environment he is exploring. By working closely with children, it might be possible to create a microworld that they feel engaged with. The remainder of this article will discuss how the team approached this problem.

3. METHODOLOGY

To conduct this study, a methodology based on Allison Druin's **Cooperative Inquiry** [2] and Michael Scaife's **Informant Design** [11] was created.

Working with children is unpredictable, so it was necessary to create a methodology that was rigid enough to ensure a good outcome, but flexible enough to allow sudden changes.

The methodology is divided in three rigid stages: i) understanding the children's perspective; ii) solving the problem alongside children; and iii) prototype design and evaluation. Inside each stage, there will be a set of goals, not a set of rigid activities. This allows a flexible planning that depends on the available information during the process. Activities to solve the goals defined for each stage are planned on a weekly basis.

The first stage, understanding the children's perspective, will be composed of research activities, to understand the context of the project and to learn more about children. These activities aim to answer three questions: i) how do children perceive music? ii) how do children interact with technology? and iii) how do teachers see music and technology?

The second stage, solving the problem alongside children, is the critical stage of the study. It is the stage where the concept of the tool, the microworld, will be generated. It will be formed by participatory design activities, where a team of children designers will tackle the problems that need to be solved. This stage has three goals: i) define the microworld; ii) define the requirements, and; iii) design the platform.

The third and final stage is responsible for the design of a prototype, and its evaluation.

4. DANCELIDOO, A COLLABORATIVE MUSICAL COMPOSITION PLATFORM FOR CHILDREN

This section will present part of the implementation of the methodology described in the previous section. Since this article is focused on the creation of a microworld that children can engage with, only the second stage of the proposed methodology, where the participatory design sessions takes place, will be described.

To implement this methodology, a partnership with two elementary schools was made. Both schools are located in Porto, Portugal, and its students are in the same social stratum. Due to time restrictions, both schools only made available one session per week that lasted between one hour and thirty minutes to two hours. All the activities ran in parallel in both schools, and the results compared. One of the teams that participated had five elements - three boys and two girls - and the other had six elements - three boys and three girls - all aged between eight and nine. The selection of these participants was based on their enthusiasm in participating in the project, through the execution of a preliminary activity. Besides children, there is one adult element: the conductor of this study. Both schools also have a specialized music teacher. However, music class is not mandatory, so not all of the students are in the same level in terms of music knowledge.

All the activities were performed in the school libraries, as teachers in both schools assured children felt comfortable there. The adult designer dressed casually so that children embraced him as on of their, since they usually associate adults with authority figures [12].

One problem that the team feared was that children might be disengaged with the design activities. To engage them, a little game was created. Children were told that they were a part of an experiment of a secret agency, and that from that point on they were secret agents. The agency's goal was to create a product, and that product is top-secret. Children had the chance to choose a secret agent name and a secret hand-shake. At the end of the process, all of the participants received a card with their names, secret agent names and the project name.

As section 3 describes, this stage has three goals: i) defining the microworld; ii) defining the requirements; and iii) designing the platform.

4.1 Defining The Microworld

The first goal, and the central focus of this study, is to define the microworld. At this point, deliberately, there were absolutely no assumptions regarding what the microworld could be, so that it could be genuinely generated by children.

To, hopefully, stimulate the children's imagination, an activity called "Create the instrument of the future" was organized. The goal of this activity was to generate the maximum amount of ideas of what the instrument of the future could be.

The activity started with a small brainstorm, where every element had to write some ideas on a piece of paper. After the brainstorm, each one drew the idea they liked the most. This way, several concepts were sketched at the same time. After this introductory activity, the collaborative design activity started and another brainstorm was made. This time, however, all the ideas were wrote down by the adult designer, so that they could be discussed later to sketch only the best. Children had a very hard time discussing these ideas, as everyone tried to include their ideas on the sketch. However, faced with this, one of the kids said out loud: "Why don't we connect all the instruments with wires, so that they make different sounds?".

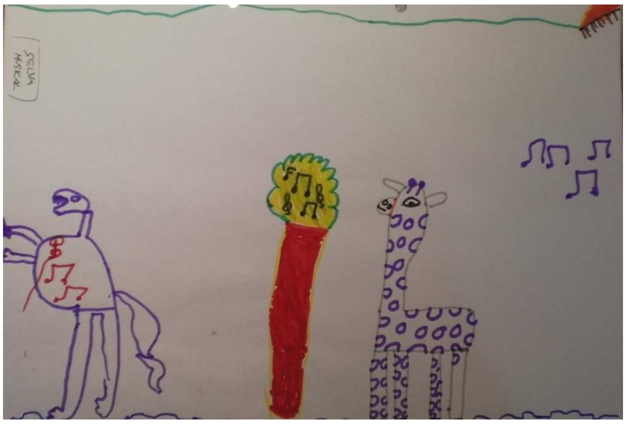


Figure 1: A possible microworld: a note eating giraffe

In total, twenty-four concepts were drawn, from spit-fire dragons that produced sounds to giraffes that ate notes from trees. A large majority of the ideas were simple combinations of existing instruments, for example guitars or flutes, with other elements. These elements were objects, for example flowers or buttons, or human characteristics, such as arms, legs, mouths and eyes. After the session, all the sketches were analysed by the adult designer. The idea was to use the sketches as inspiration of possible microworld concepts. The selection of this sketches was based on: i) the enthusiasm shown during the session; ii) the experience they could provide, in terms of engagement; iii) their contribution to the projects goals.

Although there were several possible microworld concepts, none of them were satisfiable. As such, instead of planning a different activity with the same goal, it was decided to move on to the next goal: defining the requirements.

4.2 Defining The Requirements

At this point, there was no microworld concept. However, by planning the right activity to define the requirements a concept might, hopefully, emerge. As such, an activity called "I should be able to..." was created. The session was composed by a brainstorm, where each idea had to start with that sentence, followed by a group debrief. The goal of the debrief is to discuss all the ideas that were generated, eliminating the ones the team did not like. This way, the best ideas were selected by children, not by the adult designer or any other stakeholder.

During the brainstorm, both schools' results combined, one hundred and eight ideas were generated, twelve of which sketched. The fact that children were forced to start their sentences with "I should be able to" made them generate ideas that were aligned with the project's goal. Using the results of this activity, a list of thirteen possible requirements was put together.

Figure 2: One of the possible requirements: children should be able to dance

However, there was a very interesting set of similar ideas. These ideas were related to some of the results that emerged in the first stage of the methodology: the user research stage. These ideas could be the foundations for the microworld.

4.3 The Microworld Concept

During the user research stage, one of the patterns that emerged was that children loved singing and dancing. They constantly talked about how much they loved the show the school organizes in the end of the year, where the whole class danced a pop song, or how they spend a lot of time on Youtube [1] listening to their favourite songs and singing along.

During the previous activity this pattern was observed again. Children though they should be able to sing and dance in this musical game. Singing and dancing is something natural to most people, whether they are good at it or not. One of the sketches from the previous activity portrayed a family dancing to the sound of a stereo. This sparked another idea: they already know how to dance, and dance is extremely intertwined with music and its concepts - why not create a game where we have to make dancers sing and dance on a

[1] Youtube (http://www.youtube.com) is a website where anyone can share videos.

stage? The twist is: to make people dance, we have to make music!

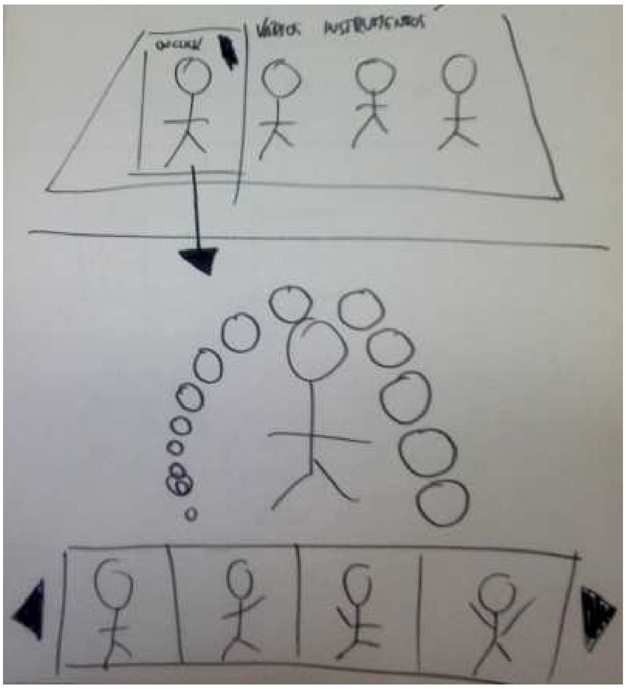


Figure 3: The first sketch of the microworld concept

The upper half of figure 3, there is a stage with a x number of dancers (in this case, four), where each one represents a different music instrument. The goal is to coordinate all dancers into a dance routine, thus composing music. The bottom half of figure 3 portrays the first solution of how one makes a dance move. The dancer is surrounded by circles that represent musical notes. To move the dancer, one has to select a body part and make it touch a musical note. The combination of these movements is what makes the dance move.

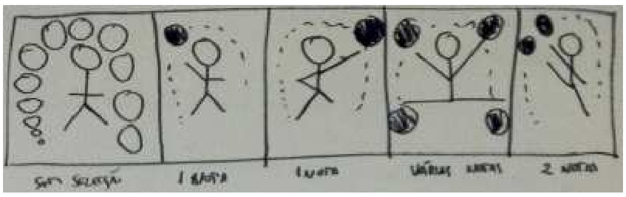


Figure 4: A detail of the first sketch of the microworld concept

A dance move can be seen in figure 4. The dancer starts by raising his right arm, playing an individual note. Then, he raises his left arm, playing another individual note. Then he moves all the members, playing four notes at the same time. Finally, he moves his right arm and leg, playing two notes.

This concept is perfectly aligned with the microworld theory: i) dance has the same rules and constraints as music, therefore allowing children to explore musical concepts through a metaphor; ii) children feel engaged with this domain, since it is something they already know how to do and love. With the microworld concept defined and a list of possible requirements, the final goal is to actually design the platform.

4.4 Designing The Platform

The final goal of the design stage is to turn the microworld concept into something tangible. Using the possible requirements, an activity called "How do you do that?" was developed.

How Do You Do That

The goal of this activity was to let children say how they would fit the requirements into a low-fidelity prototype based on the microworld concept. For example one of the requirements was: "I should be able to see who is playing with me". Children were asked on how they could do that, so that they could give ideas on how those problems could be solved.

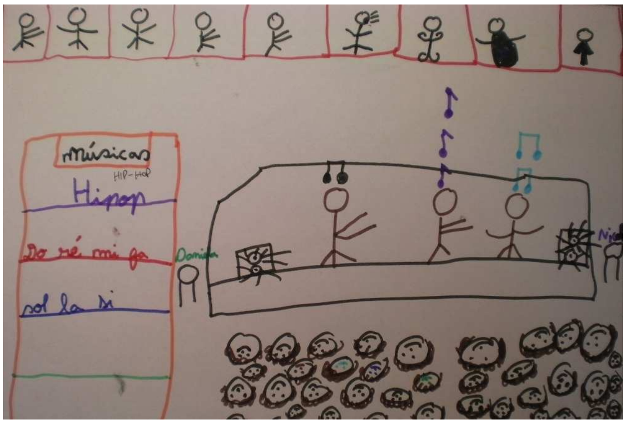


Figure 5: A possible way to manipulate the dancer

From all the activities, this was the most productive one, since children found the goal very clear. The result was a set of ideas that could be directly incorporated in the prototype. Despite this, there were some details that needed to be refined further because it still was not clear if they worked or not. Therefore, an activity called "I do not want to be a dummy!" was developed.

Refining The Ideas: I Do Not Want To Be A Dummy!

Throughout the sessions, there were some recurring issues that disturbed the activities. The first was that kids would often get into fights because others ignored their ideas, disregarding them as "stupid". Then they would sulk and did not want to participate in the activity anymore. Another issue was when they were simply disengaged with the activity and started disturbing the colleagues that were interested. The first issue yields that kids are very competitive - although they are a team, and their efforts are always for the team, they wanted their individual ideas to shine. The second issue was caused by lack of interest or distraction. Therefore an activity name "I do not want to be a dummy!" was developed. This was a game played by two teams, where a problem was given and each team had to solve it. Each team had to defend their idea in front of a jury and the other team. The best solution was then picked by the adult designer, attributing a point to the winning team. In the end, the members of the team with the least points would be dummies - and no one wants to be a dummy! This way, it was possible to use their competitive spirit to increase their focus and productivity in the tasks.

Figure 6: A possible solution for a problem posed in the design session

The result of this activity was a set of possible solutions to the problems that were present in the prototype. The activity worked great, since kids were, for the first time, defending their work and ideas. This made them realise that they really needed to think deeply to find solutions to the problems, or they would loose. Also, inside their teams, they collaborated better than with the whole group.

However, there was one thing that backfired. In the end of the session, one kid started crying saying he did not want to be a dummy. Maybe next time it will be a better idea to reward the winners, instead of punishing the losers.

4.5 Overview Of The Prototype

When this stage ended, a low-fidelity prototype was designed by the adult designer. This prototype was later evaluated with children that were not part of the team several times.

This prototype is composed by two main areas: i) the dance stage, where players can assemble their dance moves into a routine; and ii) the dance move editor, where players can create the dance moves.

Dance Stage

The dance stage prototype has two elements, as seen in figure 7: i) the stage, on the bottom, where the dancers are positioned; and ii) the tracks, on the top, where the dance moves can be assembled. Each dancer has its own dance moves and plays a different instrument. More dancers means more complexity in the music being created. Each dancer also has its corresponding track. A dance move has a little peg and a hole, just like a puzzle piece, so that children can chain the them together into the right track.

The dance stage area was prototyped using paper because this project had a very tight deadline, and the team decided

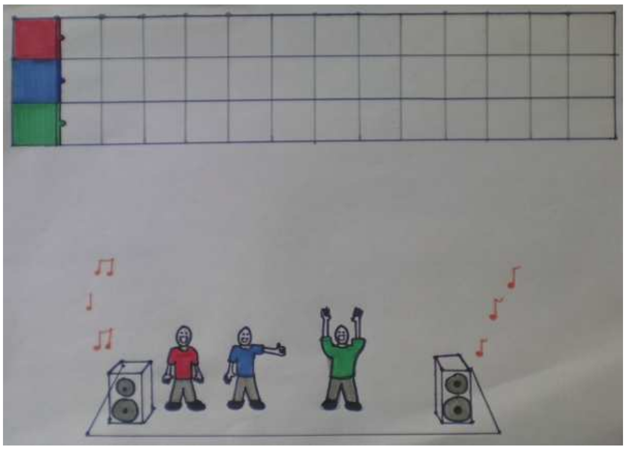


Figure 7: The prototype of the dance stage

focus on the other area of the prototype: the dance move editor.

Dance Move Editor

This prototype was actually implemented because it was important for children to: i) see an immediate reaction to their actions; and ii) hear the melodies they were creating.

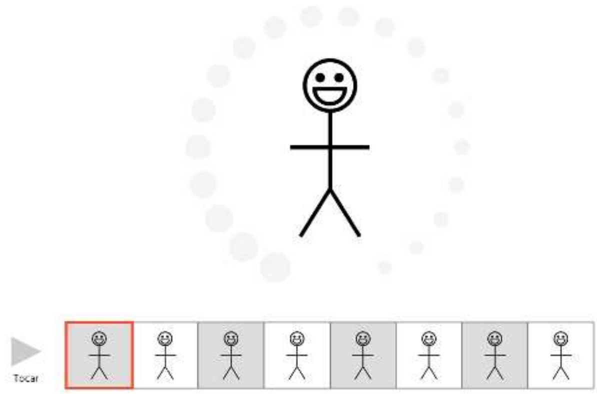


Figure 8: The prototype of the dance move editor

As seen in figure 8 It is divided in two areas: i) the dancer, on the top, where children can create a single movement; and ii) the beats, on the bottom, where children can sequence the single movements they creating, resulting in a dance move. To make the dancer move, one has to select a body part and one of the circles that is around him. Each circle represents a note, and they are laid out from low to high (big to small). Since the dancer has four body parts, two arms and two legs, one can play one to four notes at the same time. To create the dance move, a sequence of movements is necessary, defined on the bottom. That representation corresponds to the eight notes of a quaternary compass (a quaternary compass has four major beats, and this representation also shows the beats between them). When the child saves his dance move, it is immediately available to be used in the dance stage.

5. DISCUSSION

The application of this methodology yielded interesting results. In total, 198 ideas were generated, 85 of which sketched. These ideas are the children's vision of what the tool being developed should be. Using these ideas, and the results of user research, an appropriate microworld concept was created. Despite this, the teams that participated in this project do not represent the whole target audience. Although the concept resonates well with this group of children, it might not resonate the same way with others. However, since dancing is so natural, the team believes it resonates with other children the same way as the participants of this study. Regarding the learning facet of this project, it is hard to determine if this tool potentially improves children's knowledge regarding music and its concepts at this point. To evaluate this, a study that compares the results of a group of children using the tool with a group who does not during a long period of time needs to be planned.

The structure of the methodology, rigidly flexible, also proved to be very effective. Since the outcome of the design sessions is unpredictable, the methodology's flexibility allows sudden changes without hurting the final result. An example is when the first session did not yield the desired results and the next session was planned with that in account, that resulted in the desired outcome.

A very interesting outcome of this process is the session that used children's competitiveness to explore better results. Children got extremely engaged in the design session and were focused on producing the best results, instead of satisfiable ones. Despite this positive experience, proving that the use of competitive games in participatory design sessions can result in better outcomes needs a deeper study.

The use of Participatory Design in the creation of digital products is far from being new. However, each project has its own requirements and constraints that make it unique. We can only learn how to improve our methods and techniques if we study each others' approaches to similar problems.

6. REFERENCES

[1] T. Armstrong. *The Foundations of the Theory of Multiple Intelligences*. New York: Basic Books, 1994.

[2] A. Druin. Cooperative inquiry: developing new technologies for children with children. In *Proceedings of the SIGCHI conference on Human factors in computing systems: the CHI is the limit*, pages 592–599. ACM, 1999.

[3] A. Druin. The role of children in the design of new technology. *Behaviour & Information Technology*, 21(1):1–25, 2002.

[4] H. Gardner. *Frames of Mind*. New York: Basic Books, 1983.

[5] L. Levinowitz. The importance of music in early childhood. In *Music Educators National Conference*, 1998.

[6] L. Levinowitzi, P. Barnes, S. Guerrini, M. Clement, P. D'April, and M. Morey. Measuring singing voice development in the elementary general music classroom. *Journal of Research in Music Education*, pages 35–48, 1988.

[7] M. Muller, D. Wildman, and E. White. Equal opportunity: Pd using pictive. *ACM*, (36):64–65, 1993.

[8] B. Nilsson and G. Folkestad. Children's practice of computer-based composition. *Music Education Research*, 7(1):21–37, Mar. 2005.

[9] S. Papert. *Mindstorms: Children, computers, and powerful ideas*. Da Capo Press, 1993.

[10] J. Peery, I. Peery, and T. Draper. *Music and Child Development*. New York: Springer-Verlag, 1987.

[11] M. Scaife, Y. Rogers, F. Aldrich, and M. Davies. Designing for or designing with? Informant design for interactive learning environments. *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '97*, pages 343–350, 1997.

[12] C. Zones, L. Mciver, L. Gibson, and P. Gregor. Experiences obtained from designing with children. *Proceedings of the 2003 conference on Interaction design and children*, 2003.