MAESTRO

Boosting music education in the Netherlands

11 June, 2020

A Final Master Project Report by
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Client
Studio Tast

Preface

This report is the result of a one-year final master project from August 2019 till June 2020 at the Department of Industrial Design as part of the Eindhoven University of Technology. I, the writer, am Olivier van Duuren and have expertise in early product development using a user-centered design approach. In this report, I aim to present and argue the end results of the project. Before describing the project, I introduce my personal vision on design and the aim of this project. After, I will first introduce all topics relevant to understand the context in which the final design and prototype are developed. This background information helps to understand the reasoning behind decisions throughout the project. I then describe the design approach and further reason steps I take. All prototyping and testing in the first phase (first semester) of this project will be described because it has been crucial for constructing the final concept. In the second phase (second semester), hereafter, I present the final designs and final prototype as a result of the one-year project. Because of the promising results, I conceptualized a future roadmap and described further product developments. Finally, I conclude and evaluate the outcome of this final master project.


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Summary

The intention of this final master project at the Industrial Design department in Eindhoven is to present a realistic product boosting music education in primary schools in the Netherlands. My personal drive is to stimulate children to feel more affected by music and generate new experiences. The contemporary objective of the Dutch government is to have structured music education in all primary schools by 2020. However, there still are several factors that inhibit a successful implementation of structured music education. Those include, over-occupied primary school teachers, low confidence in music teaching, and tight budgets. Apart from teachers, there are also others at stake, including the primary school children, school management, external music teachers, cultural mediators, caregivers, publishers/distributors, and lastly the government. They all care about one common thing: good quality of music education for primary school children.

There is a lot of work showing the importance of music education at primary schools for the cognitive development of children. Others suggest that a tangible design is beneficial when educating music. Contemporary music educative products do not seem to successfully implement the envisioned structure. Therefore it is valuable to design a product or service which fits the agenda of a great majority of primary schools. As a product designer, it is, therefore, worthwhile to investigate in this national matter to support the Dutch government in their aim to provide structural music education.

The final concept Maestro is about stimulating and training the music skills of children in primary schools through a physical device and digital platform. With physical tiles, children autonomously learn about the constructs of music. They can freely play with all sorts of sounds to complete exercises in all music topics. Together, with other children, they can easily create new melodies and/or rhythms. The aim of these projects is to gradually progress children through the concept of music composition, in steps that connect to their age.

As a result of this final master project, a final prototype is delivered, supported by a future roadmap and further product development suggestions. Currently, it is suggested to proceed after this final master project with an elaborate user evaluation. Besides, an innovation grant is honored to also be able to conduct a feasibility study with the purpose to answer technological, economical and legal issues. If finished it is clear, whether the designed product Maestro is ready for the market.

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1 Introduction

"Hey there, welcome! This is the introductory chapter of this report. My personal vision on design will be enlightened as part of the motivation for this project. Here, I will also concentrate on introducing the project and presenting all information to understand the design space and ultimately the aim formulated in this project. Hereafter, in the second chapter, I will describe the theoretical knowledge relevant to the here introduced design space."

1.1 Design context

For the focus of this project, it is essential to frame the context in which has been designed. The domain of focus throughout this design project is 'primary education' in the Netherlands. The general aim of the project is to design a tool to boost music education in primary schools. Children from all age-groups, teachers, and school management are the most directly related stakeholders. Also, the government, cultural mediators, caregivers, publishers (or distributors) and suppliers are indirectly involved when developing a product for this domain. They all care about one thing: the quality of education for children. One on an individual level, the other on a societal level. Some provide education and others argue about the content of that education. The focus in this final master project will be the Netherlands, convening her contemporary national objectives with regard to this context. The explicit objective is to provide structured music education in all primary schools by 2020. The government has a budget available for 2020 of 25 million euros to improve music education in primary schools [12]. With that budget, primary school teachers are educated to teach music (5 million euros [34]). Besides, there are also several music-related initiatives such as 'Méér Muziek in de Klas' [28], which mostly encourage and promote music education for children on a national level. However, during this project, the consulted stakeholders claim that the national objective has not been realized yet. Since contemporary products do not seem to be achieving this either, it is beneficial to design a tool to boost music education in the Dutch primary schools. Thereupon, it is worthwhile for contemporary product designers to investigate in this national issue and aim to boost structural music education shortly.

1.2 My vision on design

Elevating human experience. That's what I believe it should be all about in design. It's everything I want to contribute to society as a professional designer. Either for children learning a new subject, or for professionals in improving their performance, or for people doing their households more efficiently. I want to stimulate and steer the development of products creating those new and better experiences for people to aid better everyday quality of life. It is crucial for product development in many sectors that multiple disciplines come together to collaboratively provide the most optimal solutions to recognized problems. I believe that interactive products can elevate human experiences the best, since people are unique and demand unique experiences. Thus, it is key to develop interactive products that are personalized and evoke different interactions with different people. See for instance all smart home devices. Once designing these interactions the collaboration between user and product becomes important to consider in the design process. Hence, the product designer should have a growing knowledge of users and their society, and also have skills in product development to iterate with different interactions. All things considered, I believe it is important as a contemporary product designer to create new or better experiences for users by iteratively develop a product up to an ideal condition.

1.3 My client

In order to deliver promising results regarding the above-described national matter (see Subsection 1.1), I considered consulting a client. The company Studio Tast [43] is a valuable asset in the development and launching of tangible product designs in the domain of education (i.e. 'learning'). Studio Tast activates organizations and people with solutions for diverse challenging issues. They work a lot with educational institutes and have already launched several educational products onto the market. Designing a tangible interactive product to improve music education is an equal interest and therefore we, Studio Tast and I started collaborating from August 2019. Together, we saw potential in the aim I set for this project. Therefore they agreed to guide me to develop a new realistic product by the end of the final master project. For me personally, a realistic product implicates that a company foresees potential in launching the product onto the market. A good target for me in convincing Studio Tast, is to collect many enthusiastic stakeholders and come up with feasible product development plans.

For the development of the product, I mainly collaborated with Studio Tast because of their product design expertise and their education-innovation know-how. They have no experience, however, with music education. Their education-innovation model is neither validated with music-related applications. Nonetheless, I believe that Studio Tast can support me in creating a product to boost music education in Dutch primary schools. (See a team photo in Figure 1.)

Figure 1. The team photo at Studio Tast.

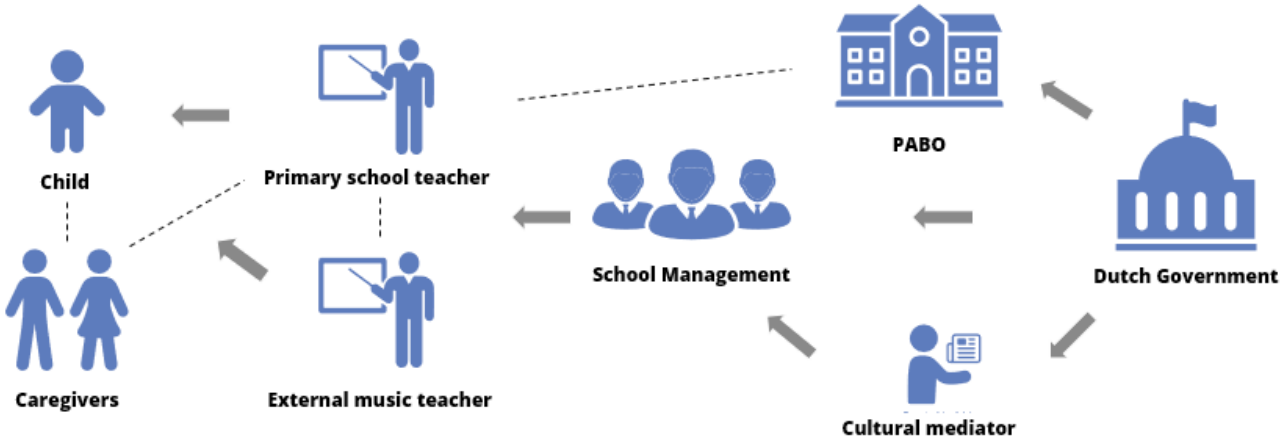


Figure 2. Stakeholdermap

1.4 Stakeholders

If designing a product in the domain of primary education there are several stakeholders to take into account. All the information concerning these stakeholders is collected via semi-structured interviews. Only the child, primary school teacher, school management, external music teachers and cultural mediators are directly consulted. After those meetings, wishes and needs of all stakeholders were extracted. These interviews were held with the purpose to map involved stakeholders in the design context (see Figure 2) .

Primary school child

One of the most important stakeholders in this project are the primary school child. The child is one of the only stakeholders also an end-user of the designed product. In the Netherlands, children in primary school are approximately 4 to 12 years old. It is valuable to design a tool that can be used by every age group because then the product is used more frequently and therefore more cost-efficient. Teachers explain that children wish for playful, colorful, and challenging education. It is also important for children to get coaching if needed.

The to-be designed product needs to educate the primary school child about music composition. Children will need to work either on individual or on group assignments. It is lastly important to note that children under the age of six generally have a disability to read. The product should encounter that issue while still be engaging and educating.

Primary school teacher

The primary school teachers are also a very important in-school stakeholder in this project, because they are educating the child a broad range of courses and skills. Teachers might switch between age groups on a yearly basis, thus are likely to teach different age groups in their careers. On a national level, there is a serious shortage in primary school teachers [44] and therefore this profession might be experienced as very demanding and dynamic. They educate in courses, such as mathematics, languages, and also cultural orientation. Dependent on the school, they occasionally get support from external teachers. Specifically, for culture-related subjects teachers tend to consult external support because they might have limited expertise themselves. For that reason, there is limited teaching of music in primary school education [17].

The to-be designed product needs to support the primary school teacher in its teaching of specifically music composition. Ideally, the teacher only coordinates and monitors the development and productivity of children that use this product. The product's role is to educate and the teacher monitors the development of children and coaches. For music acquainted teachers, the design of the product should allow for more involvement and possibilities to edit and/or add upon existing content.

Primary school management

The school management has the responsibility to monitor the quality of a school. What this quality is, is regulated by the government. A school needs to adapt to it, to obtain their licenses and varying funds. They construct yearly policy plans according to their vision and decide what is needed to reach all objectives. If a new service or product is offered to the school, generally the school management examines their policies and the available budget-related to that new offering. Then they decide whether they wish to and can work with it. Typically, they consult primary school teachers and ask if they imagine themselves working with the new offering.

The to-be designed needs to be interesting for teachers and children to use, but also has to relate to the vision of the school. If it does not resonate with the school's vision or nobody is interested it will not be purchased. Once the product is interesting for all parties, policy plans for upcoming years need to be written by the school management. In those, they request for a fund to purchase and use the new offering. The lower the required budget, the easier the fund will be honored and a school is able to acquire the new offering.

External music teacher

Some primary schools in the Netherlands have appointed an external music teacher to educate children about music. This music teacher usually visits a primary school once a week and spends an entire day teaching music to all different age groups. The topics addressed by this teacher are primarily playing with instruments and singing. The majority of classes are practical instead of theoretical and are arranged for the entire class. The regular teacher can focus on preparing or reviewing of other activities. It is unfortunate that only a minority of primary schools have appointed such an external teacher.

The to-be designed product needs to easily resonate with the practices of the external music teacher. This music teacher has its own method and lessons and can sporadically use the product or, if enthusiastic, use it on a standard basis. The product would not be fully substituting the work of an external music teacher, but rather addresses a different topic and extends the current curriculum.

Cultural mediators

There are a lot of external parties involved in stimulating and facilitating music education in primary schools in the Netherlands. Parties such as Cultuurstation, Kunst&Co and Prodas [9] [24]

[31] all act as agents to mediate between primary schools and cultural institutions. They establish an extensive network and bring culture-related products or services to a school. They are financially supported by municipalities or funding organizations such as 'Fonds voor Cultuurparticipatie' [15]. Whenever they recognize the value in services or products related to the stimulation and facilitation of music in schools, they promote the new offering to primary school managements.

The to-be designed product needs to be clear, concrete, and logical so that they can easily spot benefits and start promoting to their network. The product should be unburdening, of high quality, and matching to a school's vision to be interesting to promote for a cultural mediator. When they are convinced, they might also be able to arrange extra subsidies or funds for the schools enabling them to work with the product.

1.5 Market understanding

There have been a lot of developments on the societal level concerning music education. Most of those aim at stimulation by means of presentations, workshops and training, and even other initiatives by the Dutch government. However, in the market, there are limited products or services designed with the purpose to educate music in primary schools. There is even less designed with a focus on music composition. All related products and services related to the topic are shortly discussed below.

The majority of schools have a traditional half-hour per week in the form of singing traditional or well-known songs. This is either arranged via an external music teacher or via any music-related platform (e.g. YouTube). There are limited tangible products promoted and used in the Netherlands to teach about music composition. A reasonable amount of schools seems to work either with wooden Orff-instruments [11] or so-called 'Boomwhackers' [29]. Besides, there are two tangible interactive products found in the worldwide market. 'Beyond Tablet' [6] empowers a child to construct an interactive music creation. 'MakeyMakey' [27] enables children to design a controller with the use of everyday materials, such as bananas, to for example make a musical circuit. None of the above tangible products facilitates structured education for music composition and can be acted by children alone. The digital music tools promoted and used in the Netherlands are 123Zing [1] with 'Soundtrap', Chrome music lab [7], Eigenwijs Digitaal [14], and Gynzy's 'Muziekmaker' [16]. They allow for easy experimentation, however, all do not support the personal development of children nor address music theory.

1.6 Project aim

For this one-year project it is always aimed to deliver more than 'just' a concept proposal, but the first version of a market-ready product. It is intended to generate enough value to pursue product development after this project ended either as individual or as my client Studio Tast. The business of Studio Tast shows evident experience in releasing products and is therefore a valuable asset in achieving the project aim. My personal drive in this project is to stimulate children to experience something new and feel more affected by music. Developing a product for primary education with the purpose of learning the constructs of music could stimulate children to actively integrate music more in their lives. Currently, there are several factors that limit the successful implementation of music education in primary schools. Those include limited budgets, over-occupied teachers and low confidence in teaching music. On tha account, I argue that it is crucial to design for a solution which does take into account these factors and fits every school's agenda. Combining both my vision and personal drive and the expertise of my client creates higher chances for a successful project. Altogether, I feel challenged by this intriguing national issue and therefore want to find a solution considering all stakeholders to have a true impact.

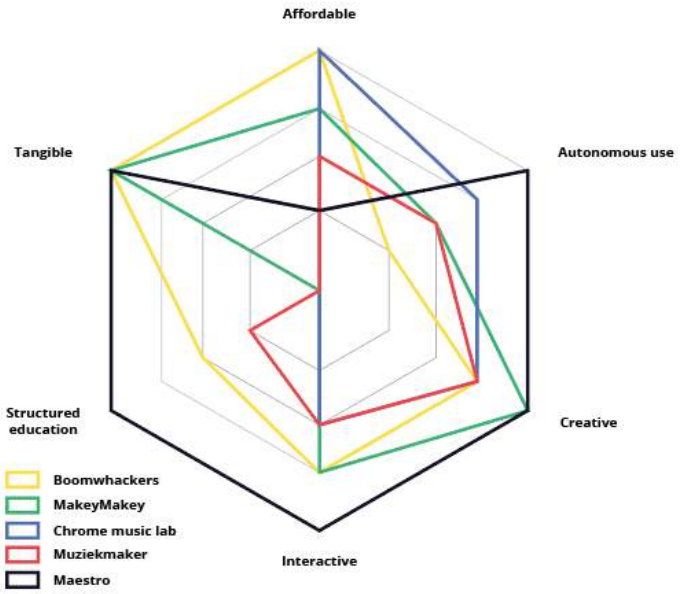


Figure 3. A radar chart of a few related offerings and the to-be designed product Maestro .

2 Theoretical Background

"There is again, just as in the first half year, much scientific knowledge applicable to strengthen the reasoning behind the developed final prototype. This knowledge is extracted from several scientific theories and related scientific work. In the next chapter I discuss the design approach before starting the concept development."

2.1 Related research

With regard to the current topic of this project, it is primarily valuable to research in the domain of music education and tangible product design. Scientific insights in these domains can certainly justify the reasoning behind the concept and prototype development later on in the design process.

Music education

From research, we learn that it is quite obvious that the government of the Netherlands investigates in the implementation of music education. Music education particularly not only improves music performance, but it also results in better achievement in domains such as verbal abilities, second-language learning, general intelligence, and non-verbal reasoning [35]. It is even shown in a literature review from Miendlarzewska et al. that musical training in childhood significantly enhances cognitive functions and causes neuroplastic changes in brain structure and function [30]. Contrarily, according to a meta-analysis of Jaschke et al. [19] there is still no striking scientific prove for the deep relation between music education and cognitive skills. Although some correlations might not have been absolutely proven yet, there is still lots of scientific research conducted on the education of music [19] [20][35]. Altogether, enough research presents the benefits of music education. Despite these benefits, teachers apparently experience issues with teaching music in class. According to research from Holden et al. (2006) [17], music is still perceived by teachers as a specialist subject. According to teachers, it requires expertise and the ability to perform. The same research presents the fact that lower teacher confidence is measured in teaching music compared to other subjects. Low confidence have to do with the fact that the mechanisms of music are usually not known to most teachers. This can make the process of teaching components of music theory rather lengthy and difficult [23]. Many non-specialist teachers do feel comfortable in leading musical activities but not with teaching its underlying theory. This relates to the research of Holden et al. [17], which suggested that teachers can be discouraged by composition and musical notation.

While research indicates the importance of music, the contemporary music teaching tools do not address the issues of music teachers. An effective method by Sarrazin [36] suggests that music educators simply need to follow four stages: Imitation, exploration, improvisation, and composition. First, let a child imitate other music performers, after which you slowly progress to music exploration. After that stage, a child can learn how to improvise, after which it eventually can start to compose music individually. When designing a product to support musical education, these phases should be considered and reflected in the product as it provides structure to the educational experience of the child.

Tangible user interfaces

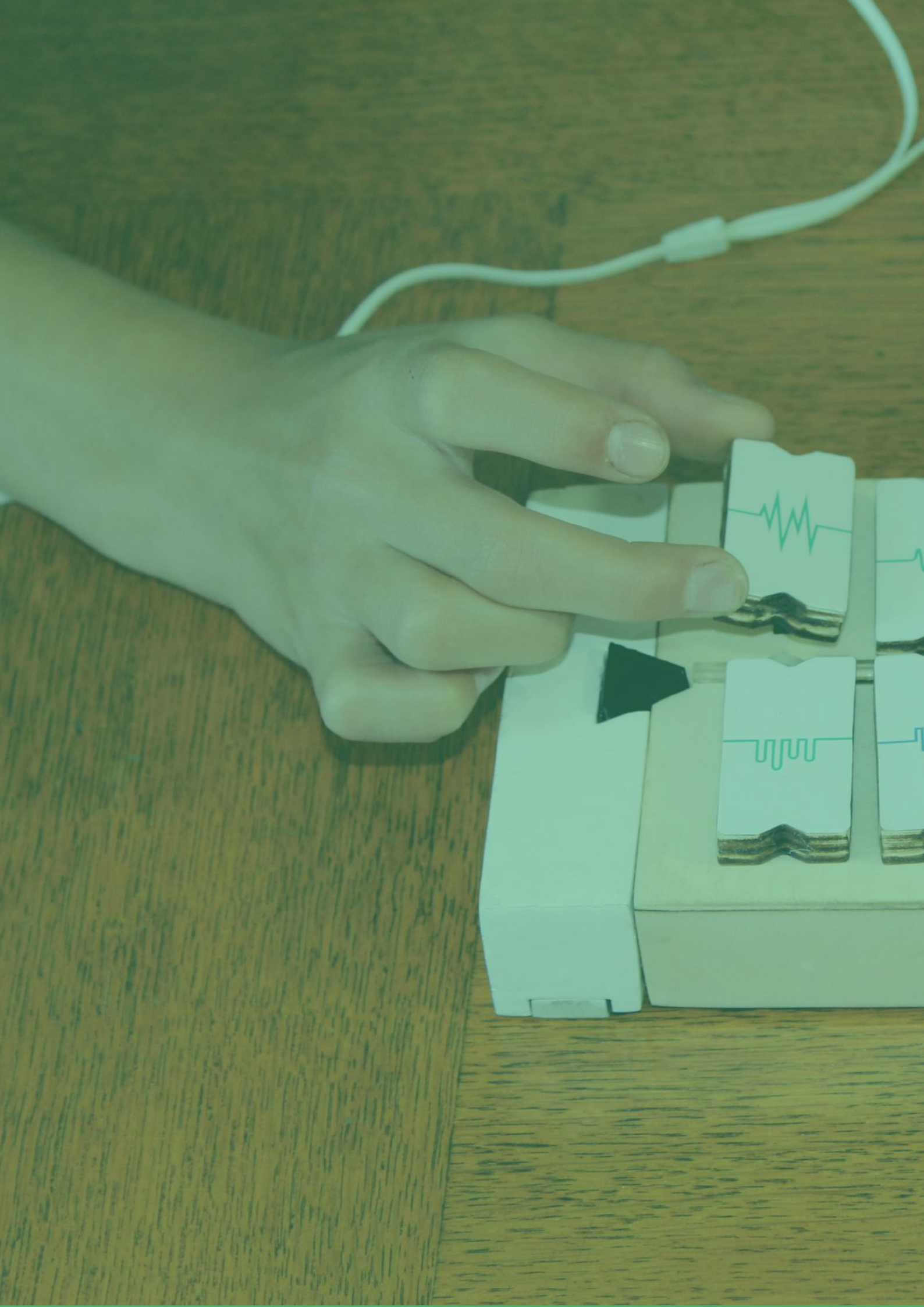
If designing an interface, designers could prefer the use of tangible user interfaces over that of graphical user interfaces. In the work of Shaer et al. [38] there are several strengths and limitations presented in which designers of tangible user interfaces do need to consider. To start, one of the biggest limitations of tangible user interfaces, however, is scalability (harder to upscale a tangible product versus a digital product) Besides, there is the risk of losing physical components, it is static and thus harder to replicate or update, and can in some cases cause user fatigue. Nevertheless, there are also some relevant advantages. The appearance of a tangible object is able to indicate its meaning and function by making use of physical affordances. Tangible interfaces also allow for parallel actions. In graphical user interfaces, users have to sequentially perform actions one by one [38].

There is also a term called 'embodied learning' [13] embracing a common strength of tangible user interfaces in contradiction to graphical user interfaces. This is an effective way of learning through the body and can be a promising approach to educate children about the abstract constructs of music. Other research by Resnick et al. [26] shows that children learn abstract concepts through bodily engagement with tangibles interfaces. According to a study by Juntunen et al. [21], it is important that (music) educators are challenged to recognize the importance of embodiment in the arts. Furthermore, tangible user interfaces, compared to graphical user interfaces, can leverage the connection of body and cognition because of tangible thinking [38]. One of the aspects of tangible thinking is the theory of distributed cognition [18], which argues that cognition also partly occurs in the world outside of the body. This is beneficial since it supports memory processes, which enforces the learning process.

Designers of tangible interactions for children can relate to a framework called Child Tangible Interaction [2] to improve their designs. This framework derives abstract design guidelines from the literature of children's cognitive development. It also highlights that an embodied understanding of concepts also provides more learning opportunities for children. All above, indicate that embodied learning through tangible user interfaces can be an effective approach in designing for music education.

2.2 Related work

Several others have academically explored the approach of tangible and embodied interaction for music education. For example, the "Marble Track Audio Manipulator" created by Bean et al. [5] with which children can create musical compositions. The tool facilitated collaborative hands-on explorations and by means of that gave a creative, playful, and engaging experience. The work shows the benefits of tangibility in the creation of music composition. A second example is 'BodyBeats' from Zigelbaum et al. [45], an interactive system that assists children in recognizing patterns in sound with their whole body. From this design, this project can learn that facilitating embodied interactions holds opportunities for learning music and patterns. Others have designed and researched successful tools that support children to learn and understand abstract sound concepts such as pitch, volume, and tempo [3][4]. The designs presented here focus on embodied interactions, which give children the handles to reason about specific music abstracts. The above-described studies suggest that tangible and/or embodied interaction are promising methods to educate children about music concepts and thus can be valuable to continue with.



3 Design Approach

"In this chapter, I discuss how I recap the developments toward my final concept. This chapter primarily summarizes, phase 1, the period from September to December, and is crucial in understanding the majority of content in this report. Hereafter, I will proceed with the additional prototype development in phase 2, described in the chapter 'Prototype Development'."

In this final master project my aim has been to develop a realistic product, instead of 'just' a conceptual proposal. After literature research, it is clarified that the best way to do that is by developing a tangible product that can offer the education without the support of primary school teachers. Hence, my focus in this project became to design a tool that directly educates children about music composition. In order to deliver this tool, a user-centered design approach is taken. Multiple prototypes and designs were planned to be tested together with both children and teachers. The project is managed through the digital system Teamgantt (see Figure 4) to quickly foresee task dependencies. Halfway, by January 2020, The aim was to have a final concept and interactive prototype ready. This meant that apart from literature research and emphasizing with all stakeholders in the first months, I had to do one iteration of prototyping and testing before January. With that in mind, I calculated enough time to execute two more in-depth iteration cycles and some time for finishing the final prototype. The prototypes can be fake at first but must get more responsive step by step to discover true user experiences. Along the way, I also have intended to construct an educational model and learning line to conceptualize the content of the tool. With the objective to deliver a realistic product, I kept all stakeholders involved, from child to expert to teacher to school management. To address the aim of this project I intend to maintain a business-oriented perspective throughout the project and consult Studio Tast with that purpose as my client. At the end of the project, the evaluation of the final prototype was postponed due to the global impact of COVID-19. It was not realistic before the end of the project to consult primary schools for in-depth user testing. Therefore, more effort was put in the development of the final prototype and the future roadmap as a follow-up if continuing this project after the final master project.

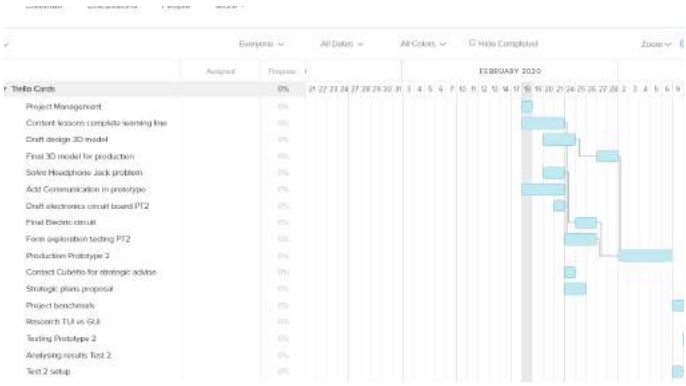


Figure 4. A screenshot of a Teamgantt workspace to manage the design process.

4 Concept Development

"In this chapter, I recap all developments and learnings leading to my final concept. This chapter primarily summarizes, phase 1, the period from Augustus to December, and is crucial in understanding the majority of content in this report. Hereafter, I will proceed with the education of music composition, described in the next chapter."

4.1 Recap

In first stages of the concept development, probes were discussed with several stakeholders. All learnings were quickly translated into a first interactive tangible prototype. This tangible prototype was a board with four slots to fit four tiles (see Figure 5). There were unique resistors used per tile in this prototype. At this point, there was only a semi-interactive digital interface developed for primary school teachers.

Figure 5. Children interacting with the first interactive prototype in test 1.

The first elaborate test was two-folded, testing the interactions and experiences of children with the tangible prototype and of teachers with the digital platform. I did a test with approximately 6 to 8 groups of each 4 to 5 children in three different schools (approximately 80 children). I carefully conducted the test and followed up on all procedures (see Appendix C for a full ethical review form). The setup of this test is retrievable in Appendix D and the consent form in Appendix A. In parallel, a test with teachers was done with three separate groups from three different schools consisting of 4 to 7 teachers teaching different age groups per school (a total of 16 teachers). The setup of this test is retrievable in Appendix E. A consent form can be found in Appendix B.

The prototype exhibited at the final demo day the 20th of December 2019 was an intermediate state of all improvements derived from the results of the first tests. For the tangible interface, the most obvious improvement was the aesthetics. It was a smaller, more compact, easy-to-hold, and colorful product. Another important improvement was the light moving along with the currently playing tile. This made playing and listening to the sounds assigned to the tiles easier to do. Likewise, the digital interface had some notable improvements. This prototype implemented both child and teacher profiles. The exercises were also more in line with the music learning line and therefore simply showed progress.

4.2 Learnings

After the first test of the digital and tangible interface with both teachers and children (see Subchapter 4.1), an extensive set of insights was collected. After transcribing and labeling all text fragments the 'Affinity diagramming' method [10] has been consulted to easily come to clear insights. Those insights were either on 'conceptual level' or on 'interaction level'. The most compelling insights are described below and determined the final concept.

Conceptual level

Both teachers and children were enthusiastic about the concept and understood it very quickly. The teachers were confident and believed the product could become part of the school's agenda. Teachers did report that there is a need for many more boards and tiles, and a separate platform for teachers and children. A final clear insight was that most of the young children had issues figuring out what to do with the prototype and older children find it way easier. Almost all children reported that they like to have at least one explanation by the teacher before starting individual or group projects.

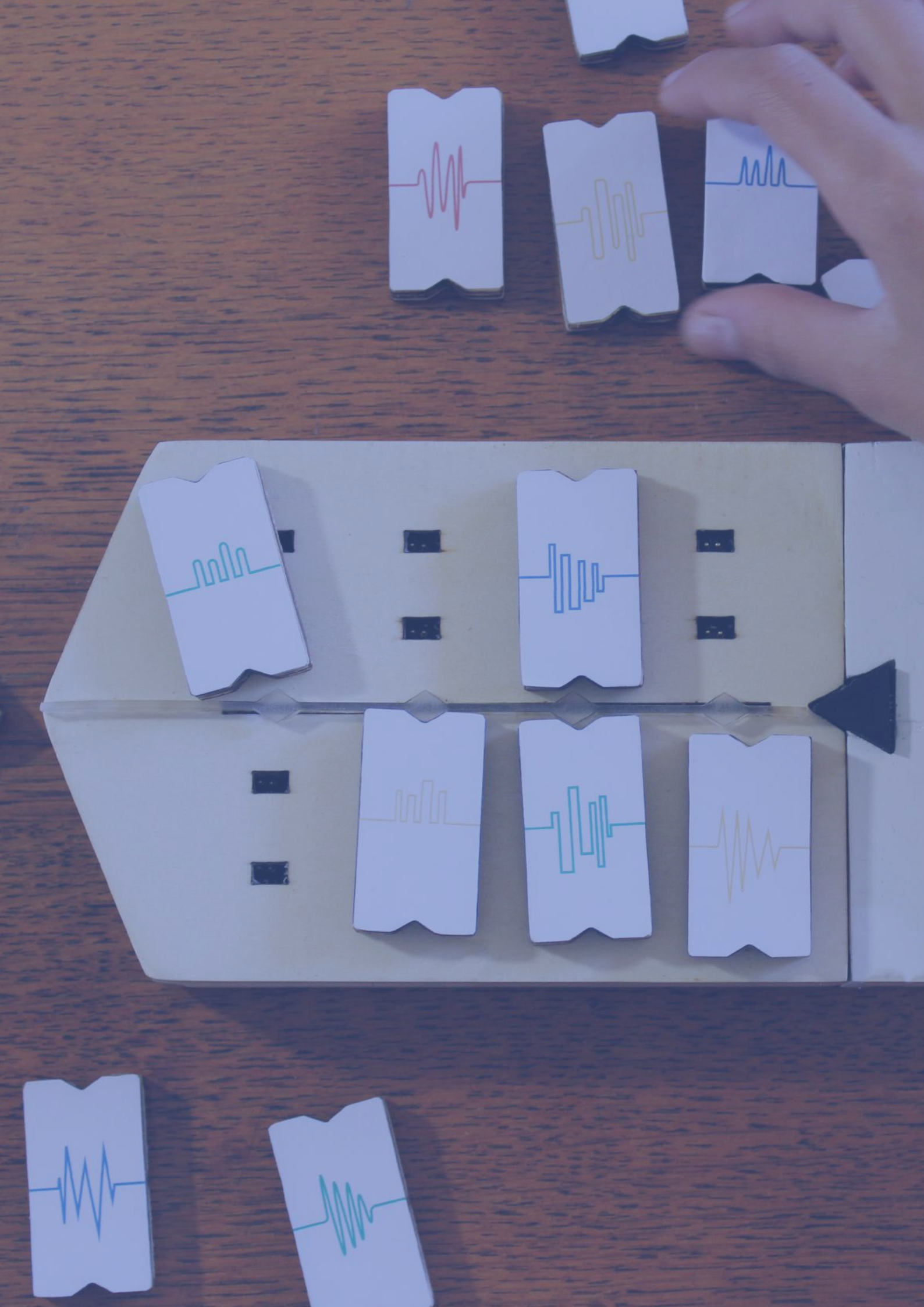
Interaction level

The feedback on the interaction level is more detailed and describes the interaction both children and teachers had with the prototypes. Among a lot of relevant insights both reported to add colorful cues to the tangible tiles to support the interaction and improve the aesthetics (e.g. stickers, colors, patterns, or shapes). Teachers argued the importance of a system which also provided some sort of correction for the children to limit the support a teacher needs to provide. Children do mind the orientation of the tile when positioning the tiles in their slots. The children also had major troubles recognizing which tile was playing when. All insights are exploited in the upcoming developments.

4.3 Final concept

'Maestro' is about stimulating and training the music skills of children in primary schools through a physical device and digital platform. With physical tiles, children autonomously learn about the constructs of music composition. They can freely play with all sorts of sounds to complete exercises in all music topics. Together with other children, they can also easily create new melodies and/or rhythms. The aim of these projects is to gradually progress children through the concept of music composition, in steps that connect to their age. Moreover, Maestro also aims to improve listening, analyzing, collaborating, and creative skills. Teachers can use Maestro in every age group, and eventually, connect it to their contemporary thematic curriculum. Maestro is mapped upon a learning line specially developed for music composition at primary schools in the Netherlands to support all teachers in their teaching. Hence, the product incorporates a structured educational model, limiting the effort of all teachers.

Teachers have a minor role in this concept, meaning that the system and the child are interacting most times. In class, the teacher usually determines a weekly list of assignments for all children. Presumably, if to fulfill the Maestro music assignment, a child would take the tangible board with a sufficient amount of tiles to its designated workspace. Then the child needs to find an available digital interface, which is in most cases available for in-class exercises, to upload a specific project. The child can work with the tool until the assigned exercises are finished and then returns the used devices so that other children can also work with it. The concept can be used in many different scenarios to match each school and supports every unique child.



5 Education of Music Composition

"In this chapter, I discuss the in-development music composition learning line and method. The setup of these tools requires the design of a large database of sounds. All that content is fundamental for the prototype development in the follow-up design and prototype developments as described in the next chapter."

5.1 Learning line

In primary school education it is essential to have a learning line for teachers to teach a subject. With this, teachers can structure their complete education every single year. The first setup of a music learning line, which was generated earlier in the project, is now revised. This is strongly related to the design of the product and thus pushes further design and prototype developments.

Together with three music experts, the content of existing music learning lines was examined and a new one specially focused on music composition was derived. One of those existing learning lines is the one developed by SLO [41]. This organization warrants the national curriculum of structured education in the Netherlands for all subjects, including music. The other learning line has a lot of resemblances and is called De Culturele Ladekast, which is a cultural initiative in the south of the Netherlands [45]. Both structure their model per age group and per skill/capacity. As a result of expert reviews and these two learning lines, a first version learning line is derived focusing solely on music composition (see Appendix F).

5.2 Method

The elements of the music composition learning line are also applied in a vertically structured method (see Figure 6 or Appendix H). This method is specially established to properly arrange all music projects in the digital platform. The method aims to teach children all related topics relevant to improvement in music composition. The topics 'dynamics', 'pitch', 'sense of measure', 'timbre', 'rhythm', 'melody', and 'harmony' were selected and are respectively listed from easy to difficult. Children aged 4 to 6 get access to the first four topics, children aged 6 to 9 get access to the first seven topics, and children aged older get access to every topic. This has to do with the cognitive development of children and is an educated guess of music experts in the field. Clearly, if a child outperforms a teacher can change the level. Per block, each topic consists of three to four projects to be able to quickly change topics for children. The first projects per topic in a block are individual projects and aim to train mainly analyzing and listening skills. The last project is a team project. In that sense, children can stimulate and/or support each other along the way (zone of proximal development [8]). This is also beneficial for a teacher since children then collaboratively educate each other. After finishing one block in all topics accessible for a child, it progresses to the next block where the same structure applies but the projects are slightly more difficult.

Figure 6. The final result of the music composition method (see Appendix G).

For now, there is a maximum of four blocks including approximately 92 projects of which 28 are group assignments. It is unclear whether this is a reasonable amount and whether it provides significant education. For now, the content of only the first block is established and presented in the digital prototype. The next steps would be, to deliver all content of all projects and review with music experts and contemporary method developers whether those are valid. It is also suggested in an expert review to include visual support in every project. This is experienced as very supportive in their own class lessons. Right now, this is not yet included, because that complicates the simple concept which currently presented.

5.3 Sound design

The content of all projects in the educational method highly depends on the design of appropriate sounds. The individual projects usually have 4 to 8 invariable sounds per project, whereas the creative projects include 16 to 32 which can be chosen freely. For technical reasons, all sounds have a 2-seconds duration and are either rhythmic or melodic.

Figure 7. Sound design in Fruity Loops software.

Currently, there is a full set of 120 sounds designed by using the software Fruity Loops (see Figure 7). There are four categories of instruments established, namely 'Strings', 'Wind', 'Rhythmic' and 'Other' (e.g. piano or voice). The reasoning behind the categories is related to the tile illustrations and can be addressed in Section X. The established sound database is the first draft and needs to be tested by children and checked by sound designers. The next steps are to design the sounds by a professional for all projects while maintaining the intellectual property of the sound fragments. Traditional child songs can be used for future development respectfully since no rights are connected. Most importantly is that still all sound fragments can be used legally whenever this project continues.


CÔTE D'A

6 Design and Prototype Development

"In this chapter, I present the final designs and how these resulted in the final prototype. Due to contemporary circumstances, the design and prototype evaluations are postponed and therefore more effort is put in the construction of a draft future roadmap, which will be described in the next chapter."

6.1 Design board and tiles

After deciding upon the technology, I created some mood boards to translate personal preference in a few categories to my designs. Most important to incorporate in the design of the physical board and tiles was the look and feel of the product. It needs to be interesting and inviting to play with to motivate the child to use it again. Other focus points are the option to connect secondary boards, ease of use, ease of transport, and lastly stimulation of creativity.

A small test with two young children was conducted with clay to explore how the tiles should be shaped (see Figure 8). The aim was to explore what kind of tile shapes could be most engaging and fun to play with. For this test sounds were played, to simulate the context of using for both participants. It was inspiring to see the results, however most of the clay samples were not applicable in the design.

Figure 8. Explorative session to discover tile shapes.

An explorative week of product sketching resulted in more important design requirements listed and described below. Over 50 board designs were sketched with focus on all above-described requirements. Two distinctive and promising designs were selected and 3D-modelled (see Figure 9). Eventually, there was a well-considered preference for a combination between design 49 and 53.

As next step, there were made more detailed digital sketches (see Figure 10). Sketches differ in shape, direction, round-offs and other small details. An important focus at this point was to come up with a clear consistent style embodying the final concept. Finally, one design was chosen and partly altered, because of prototype limitations in the dimensions. Since there were several constraints in the electronics now, the design is adjusted a little bit. It is open for discussion whether the final design will also going to be the final design once the final prototype is evaluated.

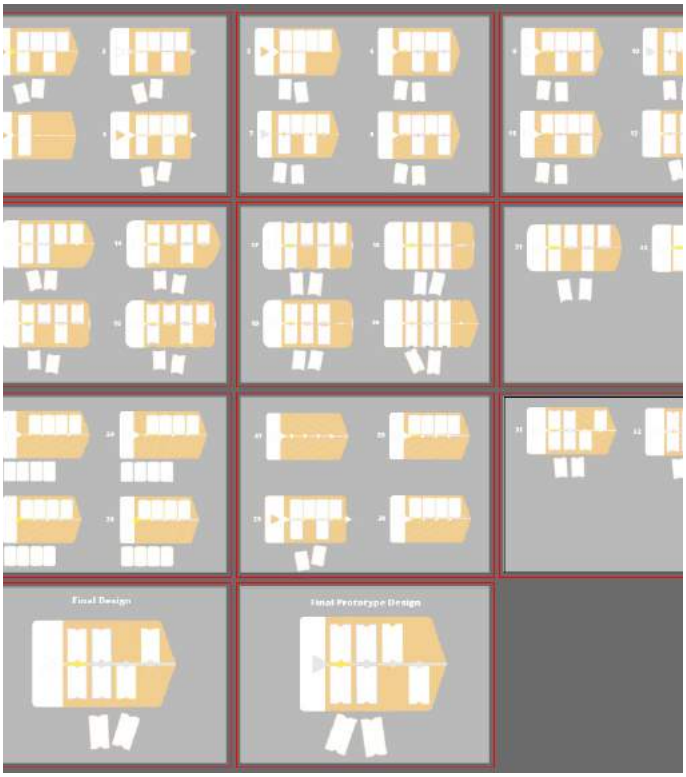


Figure 10. Complete overview of board design explorations.

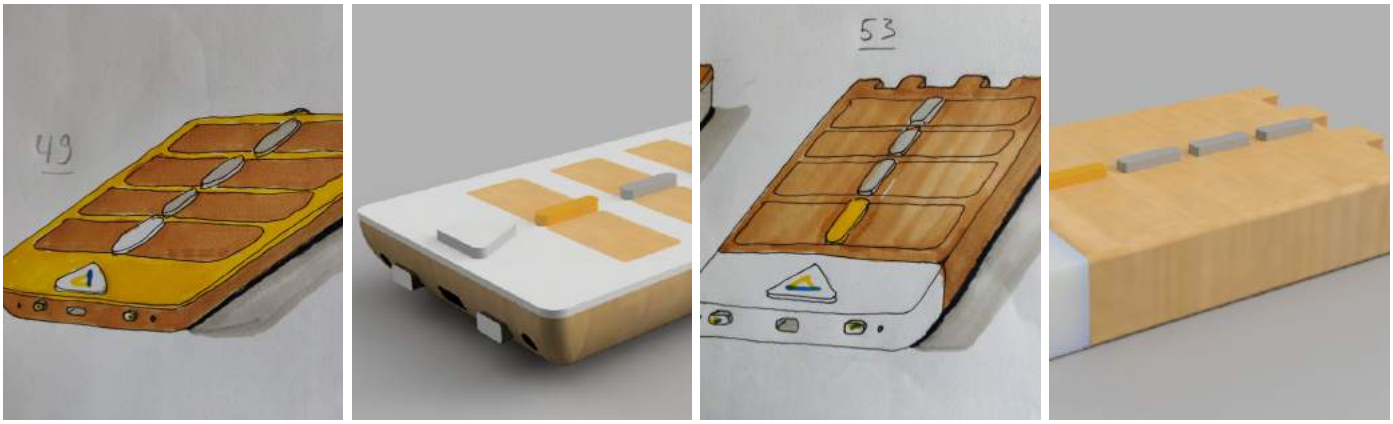


Figure 9. Two most promising designs (sketched and 3D-modelled).

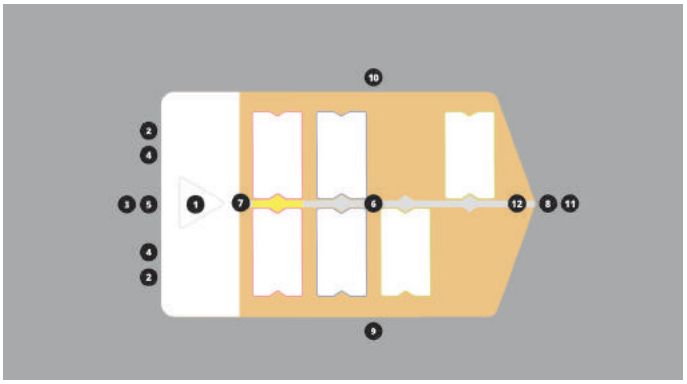


Figure 11. Final board design with functionalities numbered.

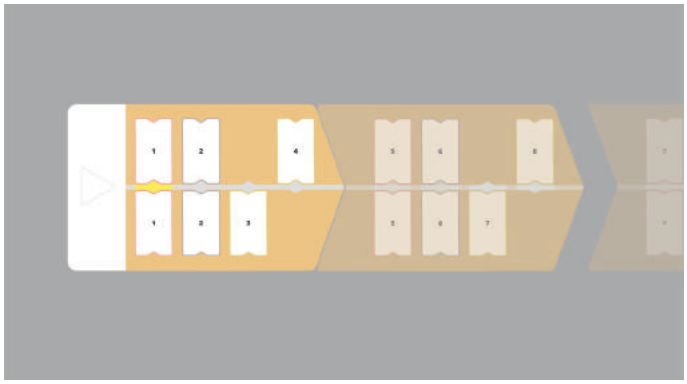


Figure 12. The main board with the envisioned secondary boards.

Essential on-board functionalities
Several of the essential functionalities of the final concept, have also been included in the final design (see Figure 11):

1) The most important function of the device is the play-button. It needs to be positioned and shaped well, making it easily visible, interpretable and push-able. To physically afford the function of this button it is designed as a triangle.
2) It has been considered that children can work best with headphones/earphones to limit concentration problems with other children. In order to enable collaboration, there are two aux plugins.
3) Making the device wireless is essential, if children work on different spots. In a class environment it is common to recharge a product by cable, just like we do with our phones. Using a non-removeable battery instead of loose batteries, gives a better experience. Moreover the product significantly thickens when positioning replaceable batteries. A simple micro-USB port is positioned on the left side of the device aligning with the play-button.
4) The other two repeat buttons are secondary functions and therefore were positioned at the left side. Both are aligned with the corresponding four tile positions.
5) An On-Off button is positioned under the micro-USB port to easily recharge the non-removable battery.

Improving interaction and experience
For a pleasant user interaction and experience a few other things have been considered:

6) Through the design of the board it needs to be clear that two tiles are coupled per column. The triangular cut-offs in the tiles and the diamond shapes on the board physically afford the positioning of the tiles. One of the elements to realize that, is to show that two tiles are playing at the same time. There are four diamonds able to connect eight tiles to at once. The diamond shapes indicate that the two tiles attached are going to be played at the same time. Magnets are positioned in the board and tiles to create a snap-effect once the tile is approaching a correct position on the board.
7) In order to specifically indicate which two tiles are playing, the diamonds will illuminate one by one through the translucent perspex. The light will show from left to right, and after finishing the row it gets back to the first position. It illuminates the perspex closest to the two tiles which are inserted in the diamond slots.
8) Since sounds play from left to right, it also physically afford the board orientation in correct use. For that reason, the right-hand side is shaped into a triangle, with a tip directed to the right, just like the play-button. For aesthetic reasons this tip is rounded-off.
9) For the experience and stimulation of creativity the tiles are easily interchangeable. With only one hand gesture one row (four tiles) can be removed from the board simultaneously. This makes it easy to start over or remove one line of sounds if wished.
10) Common practice in primary schools is to allow children to cooperate, especially in subjects such as music. Teamplay is recognized in the design through the horizontal symmetry. Children can easily work with one board by sitting in front of each other, both focusing on one row with four slots.

Extra features
Lastly, there are also some concept opportunities featured in the final design of the board:

11) The triangular shaped tip on the right-hand side is explicitly showing the possibility to add a secondary board to it (see Figure 12). This is rather envisioned as extension, instead of an important feature.
12) There is a clear distinction between the two rows and for both rows a button and an aux plugin are aligned. This is designed such that it allows child-versus-child games, where children can replicate melodies against other children. This introduces gamification and is an opportunity for the further development of the board.

6.2 Design tile illustrations

Since the tiles will be the objects activating the sounds and be the expressive part of the device, there have been illustrations designed for the tiles. There are two critical functionalities of the tile illustrations: 1) It should look engaging and playful for children and 2) the illustrations should support off-body cognition. Meaning that, once children freely move the tiles it should be easy to remember which tiles activate which sounds. For the first functionality, there are several color schemes compared. Due to colorblindness and the support for easy communication (common-known colors) the final color scheme with primary colors as illustrated in the top color scheme in Figure 13 is chosen.

Figure 13. The four draft color schemes.

For the second functionality, different themes and patterns were explored. From all iterations (see Figure 14), the set of illustrations in Figure 15 has been selected. This is because the sound-wave theme is abstract enough to relate to different sorts of sounds (e.g. a beat or a piano melody), yet it remains concrete enough to recognize a pattern and/or a shape. When playing with the tiles, the tiles can be described for example as 'the red peaky waves' or 'the yellow squared waves'. To be extra clear and consistent the sounds are represented by the final illustrations. There are four categories of instruments matched to a color: red to strings, green to rhythmic, yellow to wind and blue to others (e.g. piano or choir). It is also optional to label the sounds by 'character' and in that way relate a 'peaky' sound to a 'peaky' wave illustration. In this way the illustrations simplifies creative sessions.

Figure 14. Complete overview of tile illustration explorations.

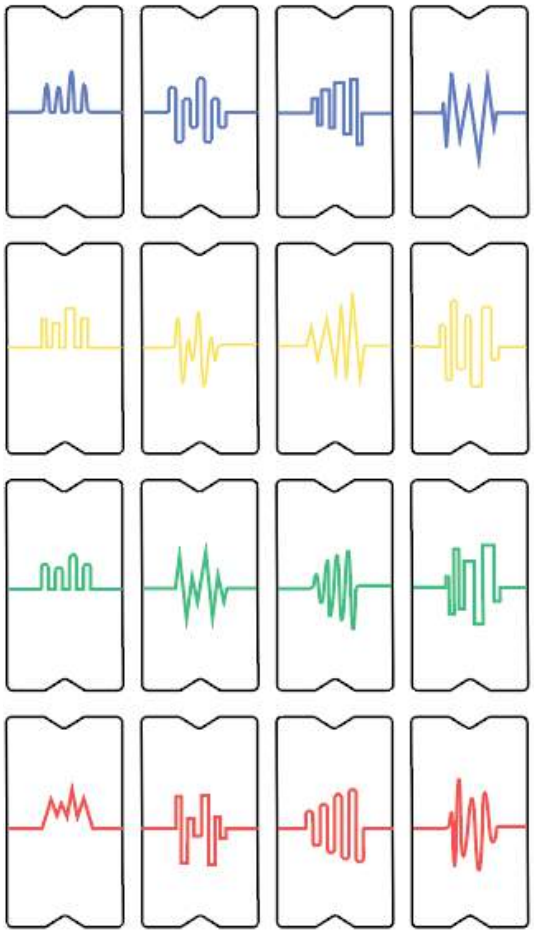


Figure 15. Final tile illustration set.

6.3 Design digital platform

The digital platform followed the designs of board and tiles and thus there are only minor developments presented here. For the redesign of the platform primarily the new color schemes were applied. Furthermore, some shapes of the prototype were incorporated in the digital platform as well. There are also some functionalities added in the design which were not present in earlier designs. The reason for this is because most content was not available at that point. The music education method, project content and the prototyping development afterwards majorly determined those modifications. In the final design presented in Figure 16, functions such as connecting to a physical board and uploading a project to that board were added. In the final design there is also more consistency in the colors and spacing.

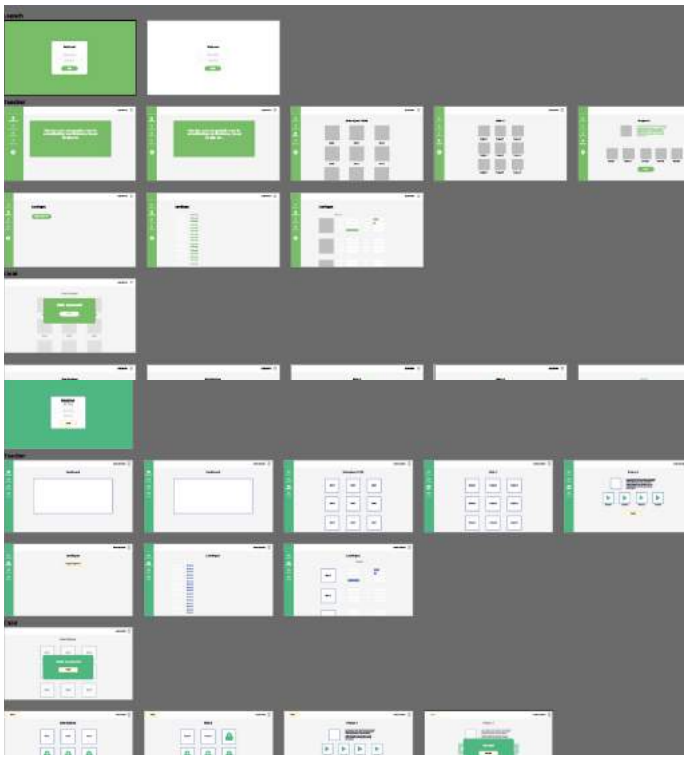


Figure 16. The old (top) and new (bottom) version of the digital platform.

6.4 Final prototype

As result of several prototypes and many stakeholder and expert reviews I came to a final prototype (see Figure X). There were a few things important in the development toward this final prototype. It needed to be determined at first, which technology was matching the best with the final concept. After deciding upon that, the physical board and tiles were designed. Besides the shape of the tiles, there were also graphical illustrations designed best matching its purpose in the concept. All the physical work was fundamental for the final design of the digital platform. All these are described respectively in detail below.

Technology

In earlier prototype development in phase 1 two technology types were explored: RFID tags and a combination of spring-loaded pins and unique resistor. Other technologies found were image recognition with camera and the use of a hall sensor grid. After several discussions and some quick prototyping it is decided to continue with the unique resistors concept. For now, this is chosen based on benefits described below. However, for market-launch more experimental prototyping and research will be needed.

The advantages of the unique resistors with reference to its alternatives are that it is 1) a relative cheap solution, 2) easy to scale until approximately 64 tiles, 3) can be processed by current technology and 4) the physical interaction is intuitive. The downside of this technology compared to RFID tags or Hall sensors is that the pins and contact plates need to be in sight and can turn out too technical for the users. A big downside of using hall sensors is that it is relative unique/new technology and therefore more expensive. It is also a bit harder to create 64 unique tiles than when using the technology concept of resistors. That is because it is required to use at least 5 magnet positions to make 64 unique combinations. For improvement of the product interaction, magnets are also assembled to snap tiles to the board. Extra steps are needed to prevent interference if also magnets are used for the hall sensor technology. A downside of RFID tags is that it seems to be even more expensive in small productions. A disadvantage of using a camera with image recognition is that the interaction changes and most importantly the user experience. The concept should support mobility in the school, but transporting the product and a camera makes it more troublesome. Besides, the image recognition needs to be trained intensively to support all kinds of soils with different illuminations. Altogether, it is decided to go with the resistors technology.

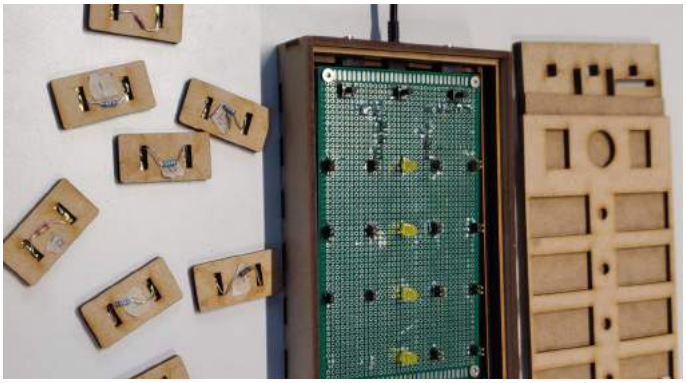


Figure 17. The hardware and electronics of prototype 3 to examine the technical feasibility.

There was a prototype developed to quickly examine the technical feasibility of the chosen technology already taken into account the new dimensions as presented in the final designs. (see Figure 17) The major difference from the previous prototype was the doubling amount of tiles and audio jacks (8 instead of 4 tiles and 2 instead of 1 audio jack). The electronics layout was already optimized for reuse in the final prototype and thus properly organized and assembled.

Hardware

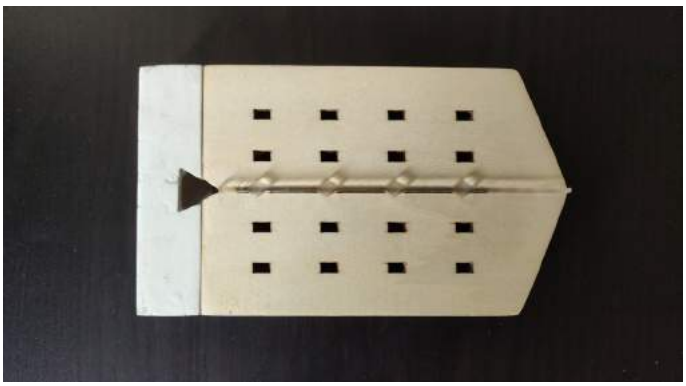


Figure 18. The hardware of the final prototype, including both the board and tiles.

The final board hardware consists of several components (see Figure 18). Namely, the bottom plate (two layers), the top plate (three layers), the casing (inside and outside walls), and an apart box for the controls. All these components were from multiplex or MDF and are created by a laser cutter. Also, the tiles, consisting of three layers were made by the laser cutter. Furthermore, there was a translucent shape of perspex needed on top of the wooden top plate to cover the RGB components and allow light feedback. The tile illustrations are printed on a paper stickered sheet and pasted on each wooden tile top surface. There are magnets assembled in the board in between the three layers from the top layer and inside the hollow tiles. The multiplex wood is finished with beeswax ensuring better aesthetical quality (see Figure 19).

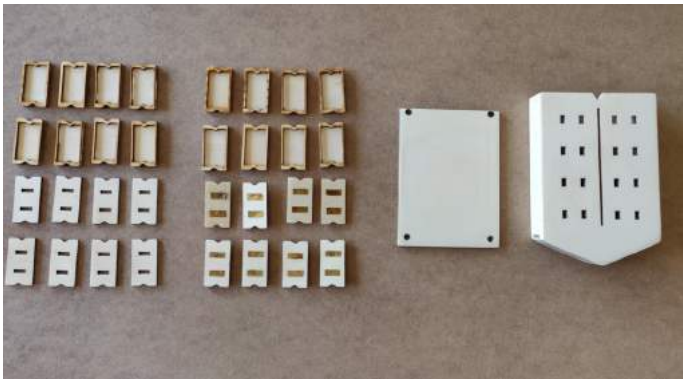


Figure 19. Finishing the hardware components with beeswax.

Electronics

For the prototype, an experimental print board is soldered with all necessary components. If possible all are soldered to the bottom (see right side Figure 20), since there is only limited space in the top layers of the board. Obviously, the layout of the print board is determined by the final design (see Appendix I for the full board layout). All components are purchased via a local electronics supplier for easy and quick prototyping. It is possible that components change when developing a PCB in the future product. All tiles have a unique resistor assembled. Technically, the microcontroller sends a high signal (5 Volt) through each slot in the board. Without a tile, the circuit is not round and returns a zero. If the tile is in the slot the circuit is complete and the unique resistor in the tile causes a unique voltage drop, which is measured by the microcontroller. Then the system recognizes a unique value and checks which sound currently is addressed to that value and plays the matching audio file. In that way, a unique tile can be detected in every position via analog pins. The prototype infinitely runs from slot 1 to 2 to 3 to 4 and then back to 1. Furthermore, the prototype communicates with the digital platform via Wi-Fi, it can be recharged by cable, and has a local SD card with all sounds from the digital platform.

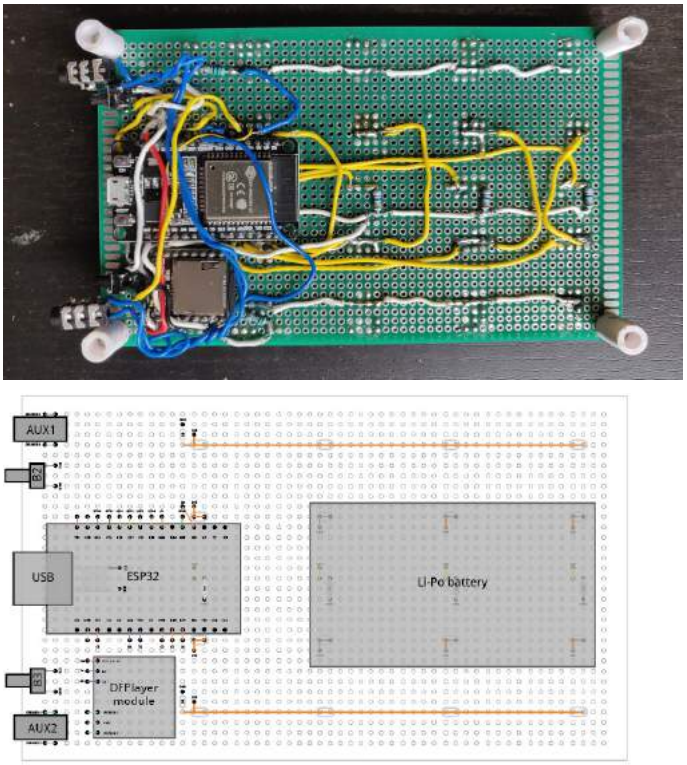


Figure 20. The bottom board layout sketched and prototyped.

Software

For the final protype there is a digital platform developed to correctly communicate and activate different projects. This final prototype does not resemble the final design but an earlier version. The role of the platform is to show all projects one by one to the child depending on its progress. After login, a child starts the last accessible project. It can pre-listen sounds before uploading the project to the board. Currently, that action sends and updates an array of sound files in an online published text file. Via a HTPP-request this data can be read via Wi-Fi by the physical board. If a child hits the 'Submit project'-button it can access the next project and so on. A teacher can also login to the same system and different functions are presented. A teacher can upload all projects, but most importantly monitor the development of the children by means of a simple overview (see Figure 21). The teacher can also adjust the level of each individual child, and see what educational method is behind the product, explaining the goal of each project. For this prototype there are no safety procedures followed and thus there is no critical data published on this website. Only fictive names are presented in the live prototype. The prototype is running from a test domain of my client and is only temporarily accessible via the URL in the caption of Figure 21.

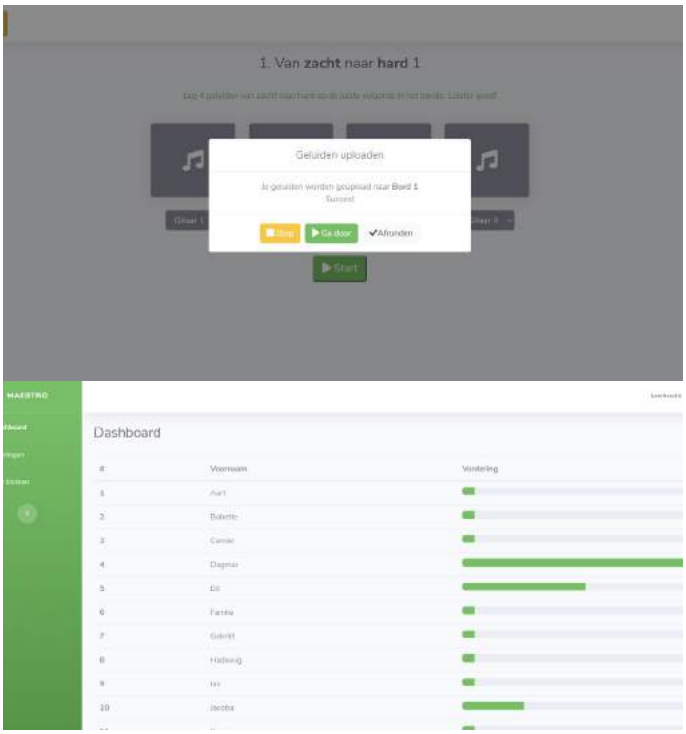


Figure 21. The final prototype of the digital platform. (http://maestro.dev1.studiotast.com/login.php - As child it is possible to log in with the username 'kind' and password 'maestro'. As teacher the username is 'leerkracht' and the password again 'maestro'.)

6.5 Prototype evaluation

It is extremely valuable to test the final prototype delivered in this final master project. On that account it is unfortunate that the current global developments in the form of COVID-19 did, despite several attempts, not tolerate evaluations of this kind in primary schools in the Netherlands. It is therefore of utmost importance that as soon as it is allowed the prototype will be tested for validation. Although, the digital platform could be tested from distance, I have not requested for help because of respect and solidarity. At the time a test would have been executed, primary schools had other priorities. Therefore, it was decided to focus on the future roadmap and further product development as described in the upcoming chapters.

7 Future roadmap

"In this chapter, I conceptualized a future roadmap of the final concept. This is primarily envisioned through a draft market research and business plan. Different elements are described and embody the potential continuation of this project. This roadmap will lead to product development suggestion described in the next chapter."

7.1 Innovation strategies

Out of many, there are a few types of innovation strategies proposed here to launch the concept 'Maestro' to the market. These are inspired and derived from the book 'Ten types of innovation' [22]. Possibly in a next stage these types are mixed up for greater potential.

Simplification

In the first strategy, there is a focus to innovate on 'product performance'. Through simplification, it is aimed to radically ease complicated matters and change the known. By this means, it elevates the user experience by allowing users to do things they could not do before. With the rise of technology, it has become cheaper to accomplish music education through an intelligent system. With the product Maestro, teachers can educate their children in music composition without much hassle and effort. It is credible, according to the literature [17], that this has become a burden for many teachers in the past decade. For this type of innovation to work, it is essential to present a clear and simple product with high ease of use. The functionality of Maestro should, therefore, be engaging and its new experiences must feel simple and limit all complexities.

Free-based

In the second strategy, there is a focus to innovate on 'business models'. For products such as Maestro, it is important that users and customers easily can discover and experience benefits. According to stakeholder analysis, it is known that the school management, who buys the system, should be convinced by the primary school teacher. Furthermore, a teacher will be convinced when children are enthusiastic about the product, and for them, causes not too much stress. Therefore, when innovating with this concept, it is essential to offer free-based demonstrations to the schools before presenting financial obligations. Because of that, a school will accept and experience the benefits with a lower threshold. Afterward, schools can be charged a premium for the full system and better experience all its benefits. The product should be engaging in its functionality to provide an unexpected value which elevates the experience of the users, both the child and the teacher.

7.2 Draft market research

Market analysis

At this point in the project the first online draft market research was conducted. A small market sample of 62 primary schools in the region of Eindhoven was examined. The 62 schools come from the two school communities SALTO (23 primary schools) and SKPO (37 primary schools). SALTO values togetherness, activeness, learning, talents, and development [37] whereas SKPO values development, responsibility, connection, and personality [40]. Values such as togetherness, activeness, talents, connection, and personality are embodied by the product 'Maestro' and therefore potentially interest the primary school communities in the region. An online search for policy plans and school guides resulted in a first insight into what schools currently use. Out of 62 schools, there were 10 schools without explicit data on their websites. From the remaining 52 schools, 14 mentioned to use the method 'Moet je doen', 9 schools mention the consultation of cultural experts/ institutions (e.g. CKE, Cultuurstation), 7 schools mention the appointment of an external music teacher and the others describe their own initiatives. Many describe to only devote half an hour per week per class to expressive subjects such as music. Most of the activities the schools arrange are not on a structural basis and seem not very expensive, for example 8,50€ per child per year for a yearly activity called 'Kunstmenu' [9]. Primary schools could for instance, through the 'Prestatiebox', receive a budget of 15,78€ per child for culture education in the schoolyear 2019-2020 [25]. However, this requires policy writings and schools usually limit the demanded effort. Clearly, more qualitative and quantitative research is necessary to get significant results. The online school guides/policies are vague and/or incomplete and the sample set of 62 primary schools is only a 0,93% market share in the Netherlands.

Future trends

For this research also some future trends in education were collected mainly obtained via Rabobank [32] The trends describe future education in the Netherlands and thus can be worthwhile investigating for the additional development of Maestro.

According to these trends, it should be all about the combination of doing something you are talented in and learn the required skills to get a good future career perspective. This personal education, which is not the same as individual education, will be provided by intelligent systems. Those systems can adapt to the unique levels of each child. Children need to learn on their own level, and their own pace, although learning from each other is also important. The budget and vision of schools can suppress the expanding use of those systems. Therefore, schools need to develop clear visions and keep up with accompanying policy plans. In class, the teacher will mostly rather facilitate and create possibilities instead of leading and educating a class. In order to accomplish that, teachers will need to extend their network. This means a future teacher needs to be explorative and use its big network and sense of coaching to provide good education. For Maestro, these trends implicate that the teacher's role is mainly coaching and the system needs to provide personalized education.

7.3 Draft business plan

To structure the different values of different stakeholders in a business plan there is a business model canvas drafted (see Figure 22 or Appendix J). The value for teachers is mostly in the independence of the child. Via big publishers and distributors, a product can reach a big market share. The benefit of collaborating with such parties is essentially the greater range and because it saves costs in marketing and sales. Primary school teachers can influence the purchase of the system and therefore they can be addressed as ambassadors of the product. This also helps to quickly increase Maestro its market share. In order to accomplish this, teachers should always be involved in the development of the product. Since generally, schools write new policy plans each year they reassess the value of products such as Maestro on a yearly basis. In order to keep being interesting for schools, software updates can be done. Because of that, and because it is common practice, yearly memberships will be offered per child. If after one year, the one-time purchased physical device shows promising results, schools can decide upon purchasing extra accessories to extend on their current system and enjoy more benefits. Optional accessories could be secondary boards, extra tiles in different graphical themes, and also extra sound packages. This all benefits customer relationships.

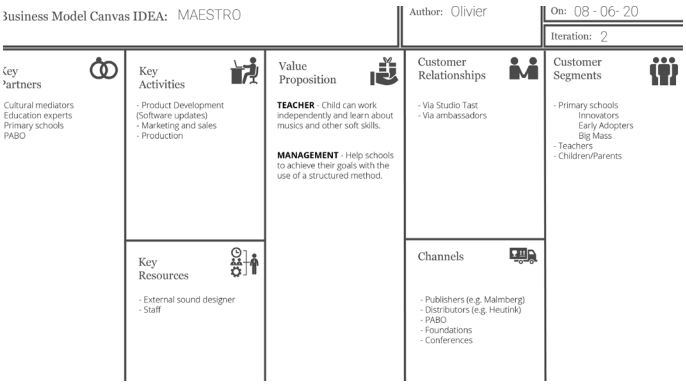


Figure 22. Draft business model canvas.

7.4 SWOT analysis

For the SWOT analysis (see Figure 23), the strengths were essentially extracted from the benchmark and competitor analysis and need to be the main value proposition of the product (see Subsection 1.5). The opportunities are mainly formulated with respect to the governmental objectives (see Subsection 1.1) and the upcoming trends in education (see subsection 7.1). To exploit these, it is important to create national awareness soon and keep on expanding through extra product accessories and distribute focus to other application domains. Maestro does still needs to confirm its cognitive benefits to convince organizations on a national level. It is still questionable whether for a limited budget, creativity can be stimulated sufficiently, and if therefore children are all challenged. Therefore, a lot of software updates will be planned for the product launch. Because of annual membership fees, these can be financed. Moreover, it is still unclear if the majority of teachers and parents see the benefits of this product and if music will get sufficient attention at a national level. To tackle that, it is considered valuable to investigate more in research and conduct longitudinal studies to prove cognitive development and convince more people. This knowledge should all be integrated into the system and demonstrated to the teachers working with the systems.

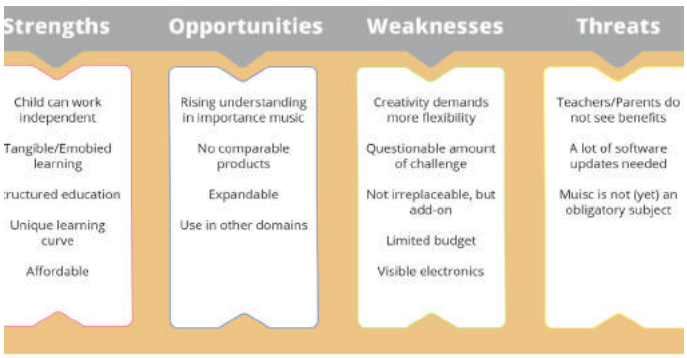


Figure 23. SWOT analysis of the product Maestro.

7.5 Grant

Considering the promising results of the concept in this project, there was a next step taken to check the feasibility. Hence, in the name of my client Studio Tast, there is attempted to request an innovation grant ('MIT-Haalbaarheidsproject') of 20.000€ at Rijksoverheid voor Ondernemend Nederland (Netherlands Enterprise Agency) [33]. By great fortune, this attempt is honored and thus the feasibility study can proceed with the aim to discover the profitability of the presented product Maestro. For this study, it is intended to research the technical, economical and legal feasibility, but also some experimental prototype development. It still is unclear whether the intended aesthetics and with that its functionality can be realized when using a different kind of (invisible) technology. Another technical concern is whether it is possible in the software to estimate the level of knowledge each child has developed through the system. Economical questions that can be answered by conducting this feasibility study are: what are users prepared to pay for the product? What are the costs for yearly maintenance? Is there a stable business case for Maestro? Furthermore, it is also intended to answer questions related to user acceptance such as: For how long can children be motivated to use the system? In what way is the teacher or external music teacher involved in this product? Many questions to be answered and therefore it is of great value to conduct this feasibility study.

8 Product Development

"In this chapter, I primarily attempt to describe what implications there are on the currently demonstrated prototype. I discuss the first developments which are needed to transform the final prototype to a market-ready product. After those final words related to the developments in this project, I conclude the final master project in the next chapter."

8.1 Prototype to product plan

The final prototype (see Figure 24) as described in Subsection 6.4 cannot be launched to the market right now and therefore some improvements are definitely needed. The concept is ready, however, the final prototype has not been evaluated yet and functionalities and interactions through hardware, electronics, and software can still change. The hardware is fully 3D-modelled (see Figure X) and ready for production, however, this is still the first version. The electronics are only in the phase of experimentation and since no PCB prototypes are developed, not ready for production yet. More research in technology is required, which might completely change the electronic board layout. The software is developed and also works only at the stage of experimentation, therefore also can still change a lot.

A first step after the final prototype evaluation would be to modify the hardware and electronics until the first version at production level. At that point, a serious estimation on the cost price of the tangible system can be made. This first draft cost price can indicate on economic feasibility. Right after, the costs of software development can be estimated and can determine whether it is valuable to proceed with the project or not. If yes, a beta version of the software can be developed. In parallel also the first production run of hardware and electronics can be started. First production prototypes of the board and tiles will be created and also the first version of the PCB can be developed. At this point possibly several iterations are needed for both the hardware and electronics. In the meantime, a beta version of the software can be running for tests. Once, the hardware and electronics are sufficient, it is wise to do some pilot studies with primary schools for a longer period. This can partly financially support product developments and again helps to improve the product. The final improvements can be implemented and then the first number of products can be produced.

8.2 Production

If still in a phase of experimentation, not all production techniques are available and optimal. However, when continuing with the production phase more techniques become optional. The final prototype is fully made with the laser cutter. This is not optimal for production since many different layers of different thicknesses are required in the current 3D-model and this is time-intensive to produce and therefore costly. For production prototypes, it is now envisioned to use both milling and laser cutting techniques. Namely, the sidewalls and two layers of the top plate can be milled. The third remaining layer of the top plate and the two layers in the bottom plate can be made by the laser cutter. Also, the tiles can be partly milled and lasered. Only the button caps need to be 3D-printed since they are custom. This first draft production plan is still demanding because three different techniques are used to produce the system. It is wise to reconsider this plan in the future because it can become too costly. Nevertheless, the production machinery is available at my client and therefore it is an issue which can be dealt with.

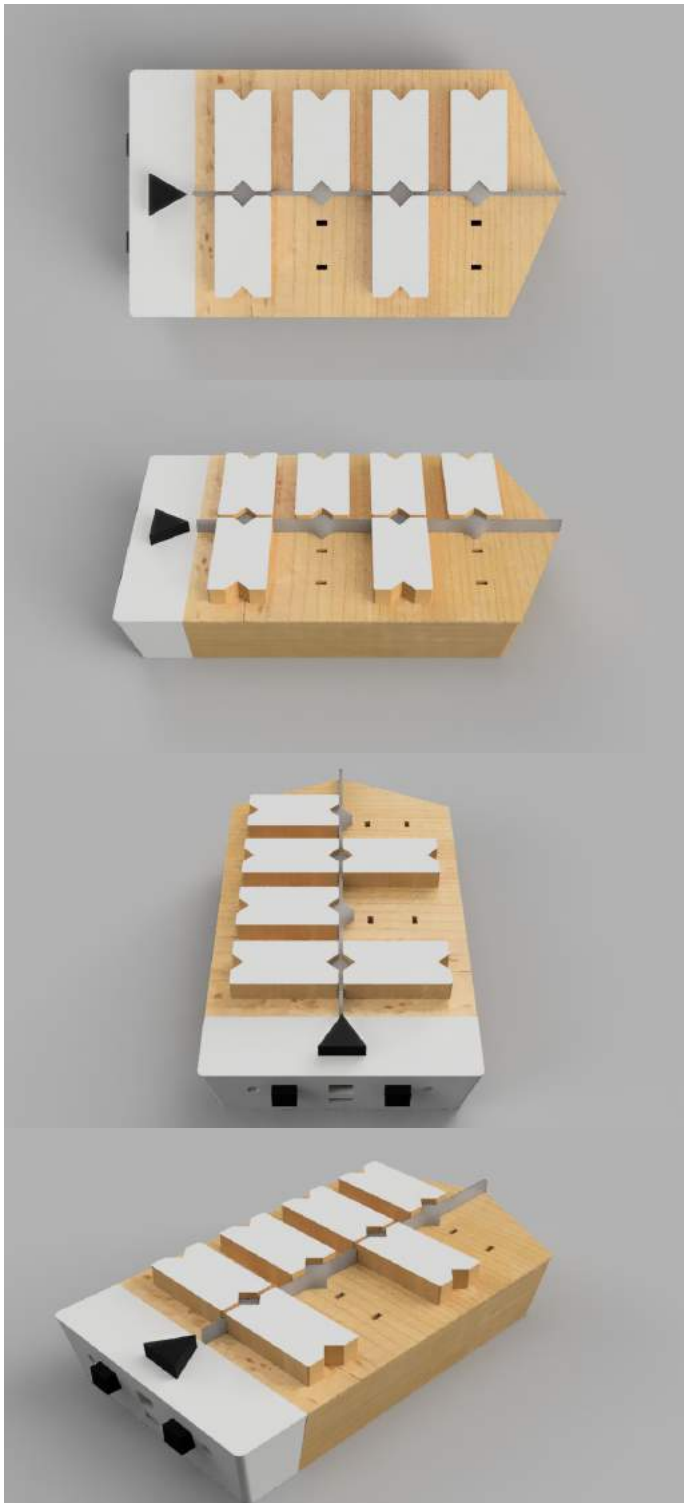


Figure 24. Renders of the final prototype.


ONE KLIK
IS ALL IT
TAKES
IPON
Olivier van Duuren

Conclusion

The aim of this final master project was to present a realistic product able to boost music education in primary schools in The Netherlands. The final concept and prototype of Maestro as a tool to educate music composition are promising according to stakeholders. Maestro generally incorporates the needs of the stakeholders since there are several iterations tested with primary school children and teachers. Furthermore, Maestro comes with a music composition learning line and method to be able to provide structured education. Children can use it independently and therefore the product tackles the limitations regarding the teacher's over-occupation and limited confidence in music teaching. A future roadmap is constructed to understand what the next steps are needed to launch the product to the market while concerning the limited budget of schools. Moreover, there are product development suggestions reported to translate the final prototype to the first production prototypes. Despite the lack of user evaluations in the final prototype, there are many topics addressed enabling us to proceed with Maestro after this final master project. It is possible to proceed and concern the feasibility of the product since an innovation grant is honored which is committed to that single purpose. This, ultimately, can lead to a new and effective boost of music education in primary schools in the Netherlands.

Acknowledgements

Firstly, I want to thank the TU/e for all the committed education and facilities I received in the past five years. I want to thank dr. ir. B.J. Hengeveld especially as my graduation mentor, because he coached me almost my entire master at Industrial Design, including this final master project.
Also, I want to thank Mitchell Jacobs as well as the other staff at my client Studio Tast for all opportunities, facilities, and feedback throughout the full year of development.
Lastly, I want to thank all experts, teachers, school managers, parents, children for all knowledge they provided me to develop the product Maestro in its ultimate state.

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Appendixes

Appendix A: Consent form Parents

Toestemmingsformulier Ouder voor muziekeducatie ontwerpstudie

Kruis a.u.b. de juiste vakjes aan	Ja	Nee
Deelname aan de studie		
Ik heb de informatie van de studie gelezen en begrepen. Ik heb de mogelijkheid gehad om vragen te stellen over de studie en die zijn naar mijn voldoening beantwoord.	☐	☐
Ik laat mijn kind deel nemen aan deze studie en begrijp dat ik kan weigeren om antwoord te geven en ten aller tijden mijn kind kan laten stoppen met de studie, zonder dat ik daar de onderzoek van een reden hoef te voorzien.	☐	☐
Ik begrijp dat deelnemen aan de studie betekent dat voor onderzoeksdoeleinden, mijn kind vragen gesteld kan worden in de vorm van een open interview en dat dit eventueel met een audio recorder wordt opgenomen, mijn kind gefotografeerd of gefilmd kan worden mits dit verder op in het formulier door u is toegestemd. Wanneer aangegeven kunnen opnamen vernietigd worden na het onderzoek.	☐	☐
Gebruik van informatie in deze studie		
Ik begrijp dat informatie die mijn kind geeft, gebruikt kan worden voor verslagleggingen, schoolrapporten, mogelijke publicaties, persoonlijke website en kennisuitwisseling.	☐	☐
Ik begrijp dat persoonlijke informatie die verzameld is om mijn kind te identificeren, zoals naam en leeftijd, niet wordt gedeeld buiten het onderzoeksteam, bestaande uit slechts 1 persoon: O.Q. van Duuren	☐	☐
Ik stem toe dat de data van mijn kind kan worden gebruikt, wanneer geanonimiseerd, als voorbeeld in presentaties of verslagleggingen voor het gepresenteerde onderzoeksproject.	☐	☐
Ik stem toe dat eventuele foto's kunnen worden gebruikt, wanneer geanonimiseerd, als voorbeeld voor presentaties of verslagleggingen voor het gepresenteerde onderzoeksproject.	☐	☐
Ik stem toe dat eventuele video's kunnen worden gebruikt, wanneer geanonimiseerd, als voorbeeld voor presentaties of verslagleggingen voor het gepresenteerde onderzoeksproject.	☐	☐
Toekomstig gebruik en hergebruik van informatie door anderen		
Ik geef toestemming aan het onderzoeksteam dat de informatie die onttrokken wordt in dit onderzoek wordt opgeslagen, mits geanonimiseerd, voor toekomstig onderzoek en als leermateriaal. In regelingen is vastgelegd dat de informatie voor maximum vijf jaar wordt bewaard op een lokale harde schijf.	☐	☐

Handtekeningen

_____

Naam van kind

_____	_____	_____
Naam van Ouder	Handtekening	Datum

Ik heb zorgvuldig alle nodige informatie aan de aandacht gebracht van de mogelijke deelnemer, en tot mijn beste kunnen, verzekerd dat de ouder van de mogelijke deelnemer begrijpt waarmee zij vrijwillig instemmen.

_____	_____	_____
Naam van onderzoeker	Handtekening	Datum

Appendix B: Consent form Teachers

TU/e Technische Universiteit Eindhoven University of Technology

Technische Universiteit Eindhoven, 19 November, 2019

Toestemmingsformulier leerkracht

Voor mijn master afstudeerproject, Olivier van Duuren, ben ik een studie aan het afnemen met als doel een boost te geven aan muziekeducatie in primair onderwijs.

U bent uitgenodigd om deel te nemen aan deze studie om een korte presentatie van mijn concept te krijgen en die vervolgens te testen. Deze test is voornamelijk opgesteld om samen te achterhalen wat er beter kan en belangrijk is wanneer er een product met dit doel ontwikkeld wordt. Gedurende deze sessie zou de onderzoeker wat foto's willen maken voor documentatie een publicatie van zijn/haar project. Voor het grondiger verwerken van input zal de onderzoeker ook lokaal een audio opname willen maken, die na analyse weer verwijderd wordt.

U bent niet verplicht om deel te nemen aan dit onderzoek of om antwoord te geven op vragen die u gesteld kunnen worden. In het geval dat u wilt stoppen met de sessie, dan kan dat ten allen tijden aan de onderzoeker gemeld worden. Verzamelde informatie zal confidentieel worden behandeld, tenzij u zelfstandig meldt dat dit niet hoeft.

☐ Ik geef **WEL** toestemming, dat er voor documentatie en publicatie foto's worden gemaakt, voor bijvoorbeeld een verslag of persoonlijk portfolio. Hiernaast, geef ik ook toestemming voor het maken van een geluidsopname tijdens de sessie, wanneer deze na analyse verwijderd wordt. Ik begrijp dat de data die verzameld wordt waar mogelijk geanonimiseerd wordt.

☐ Ik geef **GEEN** toestemming, dat er documentatie en publicatie foto's worden gemaakt.

WEL geef ik toestemming voor het maken van een geluidsopname tijdens de sessie, wanneer deze na analyse verwijderd wordt. Ik begrijp dat de data die verzameld wordt waar mogelijk geanonimiseerd wordt.

Ik begreep dit toestemmingsformulier en neem vrijwillig deel aan deze sessie. Ik begrijp dat mijn toestemming niet schaad met mijn rechten als individu.

Datum: .....

Naam leerkracht: .....

Handtekening leerkracht: .....

Datum: .....

Naam onderzoeker: .....

Handtekening onderzoeker: .....

Appendix C: The approved ethical review form (revised)

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Ethical Review Form

(Version 27.06.2019)

This Ethical Review Form should be completed for every research study that involves human participants or personally identifiable data and should be submitted before potential participants are approached to take part in the research study.

Part 1: General Study Information		
1	Project title	Boosting music education in primary schools.
2	Researcher	O.Q. van Duuren
3	Email researcher	o.q.v.duuren@student.tue.nl
4	Supervisor(s)	B.J. Hengeveld
5	Faculty/department	Industrial Design
6	Research location	Region of Eindhoven
7	Research period (start/end date)	November 2019 till July 2020
8	Funding agency	-
9	[If Applicable] Study is part of an educational course with code:	DFR215 – Project at ID – Research and Design Development (FE)
10	[If Applicable] Proposal already approved by external Ethical Review Board: Add name, date of approval, and contact details of the ERB	-
11	Short description of the research question	How can a digital-physical hybrid interface support primary school teachers to teach music composition?
12	Description of the research method	Th research includes iterations of an interactive prototype, which will be evaluated with the target users. I will use several methods, including interviewing, observation, formative usability testing, and user experience testing. All methods will be carefully conducted throughout this project with both children and teachers.
13	Description of the research population, exclusion criteria	The research is focused on primary school teachers and the children in their classes. All are representative for the research population and will be recruited via the primary schools' own existing and trusted networks. The children with whom I conduct my research are selected by the primary school teacher. The teacher has better understanding of its in-class practices and can limit the risk for children to feel excluded better than I do.
14	Description of the measurements and/or stimuli/treatments	The evaluations are aimed at getting insight in the needs, wishes and behaviors of the research population. The in-depth interviews will be conducted with the teachers or with the teacher and the children together. All in-context executed studies in which observation and discussion are important, are held under supervision of the teacher and are in awareness and accordance of all the parents/caregivers. All participants will see my intervention, which is both digital as physical. They would interact with both. For children it could be beneficial to participate, because they feel entertained. The only

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Ethical Review Form

		burden there possibly would be, is that the child does not learn anything and only evaluates the intervention with the researcher in an informal way. Teachers could participate and thus benefit to learn about new in-class practices. They only have to agree and schedule/spend some time to do so. The sessions are audio recorded for transcribing only and remarkable observations will be noted down. There will only be video recorded once this is agreed with the teacher and only with the aim to monitor the participants' hands while interacting with the intervention. When the project ends the local-stored recordings, will be deleted. To ensure that children do not feel tested on, I aim to simulate a regular music lesson. The test will be held during the afternoon when usually a music activity is. The session is 15 minutes at most and is as interactive and playful as possible. I do not ask formal questions, but rather question about their experience. The interview is not structured and therefore probably feels not like a test or hearing. I also choose to audio record the session to limit the occurrence of writing answers down. Parents will not be present during the test, because it is in regular school hours, and thus I discuss everything with the teacher beforehand.
15	Number of participants	I aim to test at 3 schools with a rough estimate of 10 different classes each. Those classes usually consist of approximately 30 children. Besides, there will be a set of teachers involved (estimated 10) from all 3 schools. If all children from those 10 classes are involved my number of participants combined with the teachers reaches 300 - 350 participants. I do not intend to do all tests with a complete class but try to have small groups of four children per test. Once I only do 2 groups of 4 children from all 10 classes I have approximately 120 participants. The number of participants thus really relies on the design process I go through.
16	Explain why the research is socially important. What benefits and harm to society may result from the study?	It is relevant to come up with a solution to educate children with music in primary schools, because it is beneficial for the overall development of children. There is no effective solution right now in the Dutch market. Possibly, but rather unrealistic, a societal harm could be that the children are not developing the intended skills.
17	Provide a brief statement of the risks you expect for the participants or others involved in the research or educational activity and explain. Take into consideration any personal data you may gather and privacy issues.	1. *Patient Privacy and Confidentiality*. I intend to have minimal personal information of my participants throughout the research. Once there is personal data stored this is only for analysing purposes. This data would be stored on a local password-proteceted hard drive. Also, the data will be accessible to the researcher only and will be deleted at the end of the final master project. For the children I will have consent given by the parents to me personally or via the school as it is usually arranged. 2. *Malfunctioning of prototype*. The prototypes will not have moving elements and there is no high electrical power involved. If a prototype will malfunction this could only be a

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		software error or a disconnected wire which cannot be harmful to participants.

Part 2: Checklist for Minimal Risk

		Yes	No
1	Does the study involve participants who are particularly vulnerable or unable to give informed consent? (e.g. children, people with learning difficulties, patients, people receiving counselling, people living in care or nursing homes, people recruited through self-help groups)	x	
2	Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children or own students)?		x
3	Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g. covert observation of people in non-public places)		x
4	Will the study involve actively deceiving the participants? (e.g. will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study)		x
5	Will the study involve discussion or collection of personal data? (e.g. name, address, phone number, email address, IP address, BSN number, location data) or will the study collect and store videos, pictures, or other identifiable data of human subjects?[1]. Please check the FAQ's on the intranet. If yes: please follow the procedure. Make sure you perform a Data Protection Impact Assessment (DPIA) and make a Data Management Plan if necessary and let the data steward check it.		x
6	Will participants be asked to discuss or report sexual experiences, religion, alcohol or drug use, or suicidal thoughts, or other topics that are highly personal or intimate?		x
7	Will participating in the research be burdensome? (e.g. requiring participants to wear a device 24/7 for several weeks, to fill in questionnaires for hours, to travel long distances to a research location, to be interviewed multiple times)?		x
8	May the research procedure cause harm or discomfort to the participant in any way? (e.g. causing pain or more than mild discomfort, stress, anxiety or by administering drinks, foods, drugs)		x
9	Will blood or other (bio)samples be obtained from participants (e.g. also external imaging of the body)?		x
10	Will financial inducement (other than reasonable expenses and compensation for time) be offered to participants?		x
11	Will the experiment involve the use of physical devices that are not 'CE' certified?	x	

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Important:
If you answered all questions with "no", you can skip parts 3 - 4 and go directly to part 5. Check which documents you need to enclose and continue with signature and submission.

If you answered one or more questions with "yes", please continue with parts 3 – 5.

Part 3: Study Procedures and Sample Size Justification

1	Elaborate on all boxes answered with "yes" in part 2. Describe how you safeguard any potential risk for the research participant.	1 – I will ask all teachers to sign a consent form which I will hand over at the start of their involvement in this study. I will in collaboration with the schools get consent from the parents of the children with which I am going to test the intervention. Usually, this is taken care of by the schools already from subscription. I intend to explain and pilot my tests with the teacher of those children at first. In this way I want to make sure that the children will not be put in a vulnerable position. If possible the teacher can supervise my sessions with the children. I mailed the teachers with a consent form to forward to all parents. The teachers ensured to inform the parents about it and decided which children could participate in my study. 11 – Usually in the field of Industrial Design we iteratively test our prototypes with a target group before the stage of 'CE' certifications. My prototypes are developed carefully and in this case have no harmful aspects such as a high voltage or sharp edges. Half of the prototype is a digital interface which is demonstrated and tested with on screens from devices owned by the involved schools. This prototype is stored with the researcher only and once tested at the primary schools, the researcher will be present at all times. The Li-Po battery inside the prototype is stable and safely protected by the prototype casing. If needed the battery can be reassembled easily and fastly.
2	Describe and justify the number of participants you need for this research or educational activity. Also justify the number of observations you need, taking into account the risks and benefits	My goal is to develop a realistic new product for primary education with a focus on music education. For this study, it is important to test both with teachers and with children. I would like to consider all children age groups in different school systems (e.g. Montessorri, Jenaplan etc.) to develop a viable product. Hence, I want to test with a large group of participants for better and more credible results. In the field of Industrial Design we iteratively test our prototypes with the target group making sure we create something valuable. Around 4-5 test moments will be needed throughout the whole period of 12 months to properly develop the product.

Part 4: Data and Privacy Statement

1	Explain whether your data are completely anonymous, or if they will be de-identified (pseudonymized or anonymized) and explain how	I only need personal data for analyzing and contact with my participants. Those are stored on a local hard drive and pseudonymized once used with others outside of the research team (me). There will only be communicated by phrasing it like 'A child' or 'A teacher'.
2	Who will have access to the data?	The personal data is only accessible by the researcher (me). The pseudonymized data is used in reports, which are accessible by anyone

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3	Will you store personal information that will allow participants to be identified from their data? See VSNU draft.	☐ No ☒ Yes, and I declare I will follow the general data protection regulation (GDPR).
4	Will you share de-identified data (e.g., upon publication in a public repository)?	☐ No ☒ Yes, and I will inform participants about how their data will be shared, and ask consent to share their data. I will, to the best of my knowledge and ability, make sure the data does not contain information that can identify participants.

Part 5: Closures and Signatures

1	Enclosures (tick if applicable): ☐ Informed consent form; ☒ Informed consent form for other agencies when the research is conducted at a location (such as a school); ☐ Text used for ads (to find participants); ☐ Text used for debriefings; ☐ Approval other research ethics committee; ☐ Any other information which might be relevant for decision making by ERB; ☐ Data Protection Impact Assessment checked by the privacy officer ☐ Data Management Plan checked by a data steward	
2	Signature(s) Signature(s) of researcher(s) Date: Signature research supervisor (if applicable) Date: 1/6/20	Olivier van Duuren  01-06-2020

Appendix D: User test setup - Child

Test setup 1 met kinderen **tijd_____**

Dan vragen stellen/beantwoorden (3 minuten), uitleg concept met V) evt. samen (2 minuten). Dan de test 2 (8 minuten). Korte feedback (2 minuten)

Eerste vraagjes

In welke klas zitten ze? Welke groep?

_____

Wat vinden ze van muziek? Wat vinden ze van muziekles?

_____

Wat denken ze dat ze kunnen in muziek? Wat zouden ze willen kunnen in muziek?

_____

Uitleg concept

Test 1

Waar moet het geluid vandaan komen?

_____

Hoe zouden ze het geluid willen activeren? Wanneer begint het met spelen?

_____

Hoe activeren we een opdracht? Kunnen jullie dat zelf?

_____

Test 2

Wat doen ze met de geluiden?

_____

Snappen ze het concept (tweedeling)

_____

Wat vinden zij wat de rol van kind en rol van leerkracht moet zijn?

_____

Overige observaties

_____

Appendix E: User test setup - Teachers

Test Setup Teacher

Procedure

- Consent forms
- Pitch concept
- Demo tangible prototype
- 4 Use case scenarios
- Discussion

Use Case Scenarios

1. Stel je bent dit jaar geen groep 4 leerkracht, maar een groep 2 leerkracht. Wat zou je doen?
2. Stel je thema is Water en je gaat interactief voorlezen met je groep 2. Je wil 4 geluiden toevoegen die te maken hebben met het verhaal en dit verhaal gaat over een boswandeling. Wat zou je doen?
3. Stel je wil de kinderen van groep 2 een variatie laten maken van het liedje 'Lang zal ze leven', omdat er iemand jarig is. Wat doe je?
4. Stel je wilt je kinderen leren hoe het liedje Vader Jacob is opgebouwd. Je hebt vorig jaar met groep 4 Vader Jacob gedaan met 8 tegeltjes maar denkt dat dit te moeilijk is voor groep 2. Wat zou je doen?

Trigger Questions

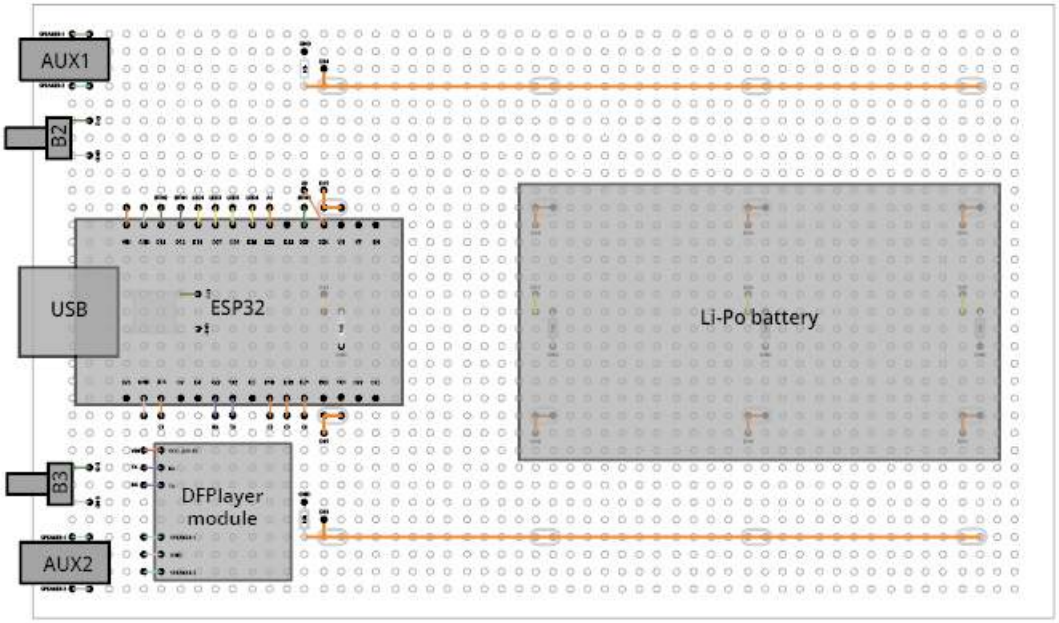
nr	Question
1	Begrijpen ze het concept?
2	Kunnen ze bovenstaande vier scenarios uitvoeren?
3	Zouden ze vertrouwen hebben met dit systeem?
4	Wat denken ze dat hun rol in het systeem is?
5	Wat denken ze dat het kind de rol is?
6	Voor wat voor dingen zouden ze het gebruiken?
	Op wat voor een momenten?

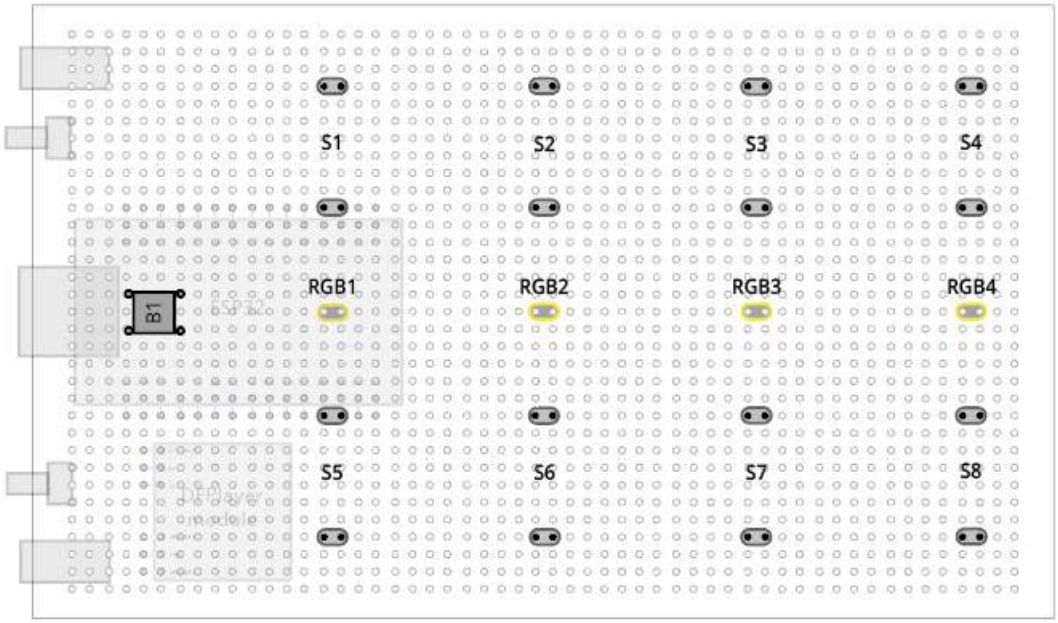
Appendix F: Music composition learning line

Leerlijn Muziekcompositie

	Leerjaar 1 & 2	Leerjaar 3 & 4	Leerjaar 5 & 6	Leerjaar 7 & 8
Reflectief vermogen	De leerling kan met aandacht luisteren naar een muzikale uiting van zichzelf, groepsgenoten	De leerling ontdekt bewust dat er verschillende soorten muziek/zang zijn en kan onderscheid maken tussen muziekstromingen	De leerling kan een associatie leggen tussen een verhaal en de muziek	De leerling kent en herkent de gang-bare muzikale elementen: melodie, ritme, maat, tempo, timbre, en har-monie uit diverse culturen en stijlen
	De leerling toont zijn gevoelens bij eigen of andermans klank- en muziekstukjes	De leerling kan op basis van klankkleur het muziekinstrumentarium herkennen en benoemen	De leerling kent/herkent vormprincipes zoals herhaling, contrast en variatie maar ook vormeenheden zoals motief, thema en muzikale zinnen	De leerling kent verschillende instrumentengroepen en herkent de belangrijkste instrumenten aan hun klankkleur
	De leerling kan muziek die eenvoudig is van structuur en met een eenduidig karakter herkennen en benoemen	De leerling kan melodiefragmenten herkennen in een muziekstuk	De leerling kent verschillende instrumentengroepen en herkent de belangrijkste instrumenten aan hun klankkleur	De leerling kent compositievormen zoals canon en variatievormen
Creeërend vermogen	De leerling kan de puls en ritme spelen bij liedjes	De leerling kan de puls en ritme spelen bij liedjes	De leerling kan m.b.v. leerkracht/professional korte speelstukjes ontwerpen, noteren en muzikaal uitvoeren	De leerling kan klankstukjes componeren waarin een ontwikkeling plaatsvindt (bv. Herhaling, ritme, stiltemomenten) en deze noteren
	De leerling kan korte speelstukjes maken met herhalingen	De leerling kan klankstukjes met herhaling en contrast (bv. Hoog/laag en zacht/hard) maken, grafische symbolen bedenken en spelen van circa 1 minuut	De leerling kan experimenteren met verschillende klankkleuren en bespeelmogelijkheden die passen bij het instrument	De leerling kan experimenteren met verschillende klankkleuren en bespeelmogelijkheden die passen bij het instrument
	De leerling kan op eigen wijze zijn muzikale ideeën vormgeven m.b.v. leerkracht/professional en presenteren in kleine groepjes	De leerling kan op eigen wijze zijn muzikale ideeën vormgeven m.b.v. leerkracht/professional en presenteren in kleine groepjes	De leerling kan op eigen wijze zijn muzikale ideeën vormgeven m.b.v. leerkracht/professional en presenteren in kleine groepjes	De leerling kent de basisprincipes van de traditionele muzieknotatie

Appendix H: Electronics board layout of final prototype





Business Model Canvas IDEA: MAESTRO

Author: Olivier

On: 08 - 06- 20

Iteration: 2

Key Partners

- Cultural mediators
- Education experts
- Primary schools
- PABO

Key Activities

- Product Development (Software updates)
- Marketing and sales
- Production

Key Resources

- External sound designer
- Staff

Value Proposition

TEACHER - Child can work independently and learn about musics and other soft skills.

MANAGEMENT - Help schools to achieve their goals with the use of a structured method.

Customer Relationships

- Via Studio Tast
- Via ambassadors

Channels

- Publishers (e.g. Malmberg)
- Distributors (e.g. Heutink)
- PABO
- Foundations
- Conferences

Customer Segments

- Primary schools
  - Innovators
  - Early Adopters
  - Big Mass
- Teachers
- Children/Parents

Cost Structure

- Website domain & hosting
- Development costs
- Production costs
- Marketing & Sales

Revenue Streams

- A free demonstration to get the users motivated and involved
- Digital platform membership per child per year.
- One-time purchase of physical product
- Extra accessoires
- Grants (government)