Technology Supported Music Education:

Using colored lights in instruments to provide feedback to beginning generalist teachers

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Abstract

Music in primary education is important for children's development since it builds confidence and creativity, brings variety in the learning methods and it promotes learning about culture. However, primary school teachers often lack competence and confidence in their knowledge, resulting in deficiencies in teaching music. Therefore, (pre-service) teachers educating music to a primary class, typically containing between ten and thirty students, should be supported in noticing if, when, how and/or why a child needs teacher-guidance. This project focusses on the guiding of beginning/pre-service teachers who have to teach children about rhythmic synchronization and entrainment. It does so by developing and testing supporting technology that provides color-based feedback incorporated in the to-be-used instruments. Due to limitations of the COVID-19 situation in early 2020, no real-life user tests could be done using actual instruments. Instead, a simulation has been built that represents a real-life class of students. We test the use of colors as a means to indicate how the rhythms are being played by the children. Variations of colored feedback were filmed and shown to pre-service teachers in a user test. They discussed their opinions and preferences. The main outcome of the user test was that the lightening instruments were fun, motivational, innovative and useful but instruction is needed and some improvements could be made regarding managing chaotic situations and limiting demotivation among the children in case of difficulties. The prototype could be improved by incorporating gamification elements, a clear instruction including how to use the instruments, lesson-plan proposals and difficulty gradations per exercises and making the feedback a bit friendlier towards children. To conclude, the lightening instruments are supportive equipment for the teachers, yet, some adjustments or additions could be made to improve the supportiveness of the instruments in a music class.

Key words: primary education, color-based feedback, rhythmic synchronization and entrainment, lightening instruments, music

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CONTENTS

Chapter 1 – Introduction

In primary education, the demand for good quality music education is increasing. Yet, music classes are mostly given by generalist teachers and due to the lack of time in their own education, generalist teachers were not educated properly on how to teach music. This results in a lack of competence and confidence in their knowledge, resulting in deficiencies in teaching music. As a consequence, generalist teachers often skip, or reduce, music classes when educating at a primary school (Wiggins, & Wiggins, 2008; Joseph, 2015) and if they teach music at all, the quality tends to be poor. When something in a music class is going wrong among the children, the teachers have no idea at what point during class it is going wrong, or which of the children need some extra support. Additionally, the teachers do not know how to act when a child needs support.

To find a solution for this problem, this project the challenge is to find suitable technology that is able to support the (pre-service) teacher while teaching music to a primary class typically containing between ten and thirty students. Our own developed technology focusses on guiding new teachers in observing rhythmic synchronization and entrainment. By using the technology, the (pre-service) teacher should know or see easily if, when, how and/or why a child is in need of support from a teacher while making music together in class. The feedback received from the technology should be clear for the teacher and not add substantial cognitive load (Hoppe, Brandmeyer, Timmers, & Desain, 2008; Mayer, 2014; Nijs, & Leman, 2014). Additionally, the feedback should not distract children from the to-be-learned materials (Nijs and Leman, (2014); Xiao, Puentes, Ackermann and Ishii, 2016). Using the technology, teachers are able to see where extra support is needed and this allows them to increase their competences and confidence in teaching music.

In this project, research is done on how pre-service teachers can be guided in teaching rhythmic synchronization and entrainment using instruments providing color-based feedback. Experiments are done using a prototype that represents (a class of) musical instruments that each light up in a certain color or brightness, based on the rhythm that is being played on that instrument. The experiment is done for various different approaches for the colored feedback in the instruments. For each of the approaches, a user test was done using a prototype that has been discussed with pre-service teachers via an interview. The aim of this test is to determine to what extent this approach of providing color-based feedback is supportive according to the pre-service teacher and how it can be improved. We wanted to determine this since the feedback needs to be clear for the teacher in order for the teacher to know how to react to the feedback given.

The first step of this project was an ideation process on how colors can be used as means of feedback on rhythm via a musical instrument. After selecting a few of the most suitable ideas, the requirements and specification of the prototype were determined. Based on these steps, prototypes were built that could simulate multiple feedback variations. Also, the user experiment was composed, in which the method of execution was developed and questions to be asked were formulated. After collecting the data from the experiment, the data could be analyzed and evaluated in order to find an answer to the question *'How can beginning teachers be guided in teaching rhythmic synchronization and entrainment using instruments providing color-based feedback?'*

The structure of the report is as follows. We start off with an investigation of the 'State of the Art' in chapter 2 followed by an explanation of the ideation phase in chapter 3. Thereafter, in chapter 4, the requirements and specifications are explained. Next, in chapter 5, the realization of the prototypes and the implementation of the experiments is explained in detail. And lastly a conclusion and discussion are written in chapter 6 in which the project is evaluated and recommendations for future research are given.

Chapter 2 – State of the Art

In this chapter, the literature research done for this project is encompassed and is divided into three parts. The first part discusses what the requirements of the feedback must be like in order to be supportive. The second part is about the use of colors as a means of feedback. And the last part is about the aspects of rhythmic synchronization and entrainment to take into account in primary education. Parts of the State of the Art are based on a literature review previously done by myself. The literature review is given in appendix 1.

2.1 Requirements for supportive feedback

This project is about a technological tool that provides feedback to beginning generalist teachers on the rhythmic synchronization and entrainment performance of the children in their class while teaching music. This tool, however, is not only visible for the teacher, but also the children themselves can see the feedback. Thus, this paragraph discusses what it is that makes feedback supportive for the teacher but makes the technological tool at the same time an endorsement for the learning ability of the children.

First of all, the feedback provided should give the teacher insight on how, when and where or by who difficulties arise in a class regarding rhythms. Wiggins and Wiggins (2008) say that (beginning) generalist teachers have difficulties with understanding the music or knowing what the musical problems are, plus the teachers often lack the required listening skills. This also means that the feedback should give the teachers a clue on what should be improved, and thus not only stating whether the children's performance is correct or not. This is because if the feedback implies that a rhythmic pattern is played incorrectly, the teacher needs additional support on how to support the children. Thus, supportive feedback should elucidate what could be improved. Additionally, Wiggins and Wiggins (2008) suggest that feedback is supportive if it shows individual differences between the children because this informs the teacher about which children need extra support in rhythmic synchronization and entrainment. If no individual differences are shown, the teacher cannot directly support the children individually.

Besides providing useful feedback, the message conveyed by the feedback should be clear and easy to understand for the teacher. In order to communicate the message as easily as possible for the teacher, the feedback should not add (extraneous) Cognitive Load (CL) (Hoppe et al, 2008; Mayer, 2014; Nijs, & Leman, 2014). Kirschner (2002) explains that Cognitive Load is a term for how much effort is required from your working memory to process information. However, working memory has its limitations, meaning that humans

cannot process all the information at the same time. Therefore, the CL required by the instruction should be limited and used as efficiently as possible following the Cognitive Load Theory (CLT) (Kirschner, 2002). To comply with the CLT, Kirschner (2002) suggests taking the three different types of CL into account. The first type is the intrinsic CL which includes the difficulty of the task to complete. In education, the intrinsic CL remains unchanged since the to-be-learned materials in a class are often pre-defined. The second type is the germane CL, this is related to the effort that is needed to actually process the instruction. And the last type is the extraneous CL, which includes how the information is transferred and this can be distracting. Thus, to manage CL efficiently in education, the extraneous load should be converted to germane load. Since the CL of a beginning teacher is high already while teaching, the technological tool should rather decrease the required CL of the teacher than increase it while teaching rhythm.

In order to prevent the CL from increasing, multiple aspects should be taken into account. For example, Hoppe et al. (2008) suggest that the feedback given should be unambiguous since else the feedback might not be immediately clear to the teacher, which might contribute to an increase of the extraneous cognitive load of the teacher. Additionally, Hoppe et al. (2008) also suggest that CL can be reduced by using feedback that feels natural or intuitive for the teacher since natural or intuitive feedback requires less thinking and thus a lower CL. Another aspect to make feedback supportive is if the feedback is given real-time (Hoppe et al. 2008). If the feedback is real-time, it is given at the moment of error, which means that the teacher exactly knows what is going wrong at which moment and the teacher can immediately provide support to the child who needs it. Thus, no memory on what went wrong by who at which moment is required by the teacher which should result in a lower CL. This also holds for the children, since they can receive support at the moment of error. However, if the feedback is given real-time, the feedback becomes an additional aspect that the teacher should process and take into account real-time which could increase the required CL. Therefore, the real-time feedback should be clear and understandable to keep the required CL as low as possible in order to be supportive for the teacher.

However, since the children are playing the instrument that is providing the color-based feedback, the children can also see the feedback. Therefore, the feedback should not distract the children, but could even contribute to the learning ability of the children. First of all, according to Nijs and Leman (2014) and Xiao et al. (2016), it is important to keep the children motivated since more motivation results in more attention to the class and this optimizes the children's learning. Therefore, the technological tool should motivate the children to participate in the class. Secondly, according to Xiao et al. (2016) children learn via sensory-motor symbolic understandings, which means that the feedback tool should allow for embodied learning or use relatable figures to convey the rhythmical aspects to the children.

Nevertheless, the feedback should not distract the children in the class. As explained before, the feedback should not increase the CL of the teacher, but this also holds for the children in the class (Hoppe et al, 2008). The children should still be able to focus on their rhythmic performance without being distracted by the feedback (Corbett, Nam, & Yamaguchi, 2016). Also, the feedback should not provoke the children to change their

behavior in another way than improving their rhythmic synchronization and entrainment. For example, the children should not want to influence the feedback given by the technological tool, since otherwise they would not learn rhythmical skills, but learn how to fool the technological tool. Besides, the feedback given should not provide a score because a score might discourage the children due to fear of failing or stress (Xiao et al., 2016). And the last thing to mention is that the technological tool should not have (many) breakdowns since this is demotivational for both the (beginning) teacher and the children in the class. To conclude, the feedback should be motivational and allow embodied learning in a class, without distracting the students.

2.2 Colors as a means of feedback

The technological tool for this project is a musical instrument that gives feedback via colored lights. Therefore, this paragraph discusses existing knowledge about colors and how they can be used as a means of feedback. Yet, even though colors have always been everywhere, up till now the effect of colors on human functioning has only been minimally researched (Elliot, & Maier, 2007; Löffler, 2014). Elliot and Maier (2007) and Löffler (2014) explain that the research regarding colors is mainly theoretically based and only very few experiments have been done regarding how the colors influence behavior. It is known, however, that colors do trigger intuitive meanings and influence people's affect, cognition, and behavior (Elliot, & Maier, 2015; Löffler, 2014; Zammitto, 2005). This means that if colors are used as a means of feedback, they can unconsciously communicate more to the users than would be thought of at first sight. Yet, how colors can influence human behavior could still be broadly researched since so far this has only been minimally researched.

Some theories have already been developed about the evolutional meaning of colors. The fact that early humans relied on colors to survive and adapt, means that possible associations can be made between colors and moods (Zammitto, 2005). Besides the associations risen from evolutionary aspects, according to Zammitto (2005) the interpretations of colors can also be influenced by personal experiences or cultures since a lot of meanings evolve via socialization processes. However, colors do not only trigger an emotional response, but humans also tend to unconsciously experience physical reactions to colors (Zammitto, 2005). In appendix 2, a table is given showing different colors with corresponding meanings, connotations and emotional relations. If the intuitive interpretation of the colors can be used for the feedback, this could prevent a CL increase.

The influence of colors is still unfamiliar, yet, there has been a lot of research on visual feedback in general in which colors can be categorized. First of all, Nijs, Coussement, Muller, Lesaffre and Leman (2010) and Xiao et al. (2016) say that visual feedback can be used to connect auditory, visual and tactile stimuli, which allows for processing the content via multiple neural connections and this causes music perceptions to develop more easily. Also, Nijs and Leman (2014) say that visual feedback can provide feedback real-time, which contributes to the supportiveness of the feedback as explained before. Additionally, according to Xiao et al. (2016) and Nijs and Leman (2014) visual feedback can support the music class since it can incorporate embodied learning, is motivational for the children and it can reinforce multiple didactic practices like free (own investigation) and guided (tasks to

complete) exploration. In short, visual feedback has many advantages and opportunities for being used as supportive feedback during a music class.

2.3 Aspects of rhythmic synchronization and entrainment in primary education

In this paragraph, the aspects of rhythmic synchronization and entrainment in primary education are discussed. Since the target group of this project includes Dutch primary school classes, the guidelines given by the SLO ('stichting leerplan ontwikkeling', or 'Curriculum Development Foundation') are the leading guidelines of this project. SLO is a Dutch foundation that develops the national learning objectives, frameworks and instruments to be used in Dutch education in cooperation with the educational field (Stichting Leerplan Ontwikkeling [SLO], 2019). SLO offers guidelines to the educational institutes which then can follow their own visions with respect to these guidelines. Thus, SLO provides the to-be-learned material and the educational institutes themselves fill in how the children should learn this. Therefore, SLO provides perfect guidelines that our enlightened instruments should follow to achieve the goals stated.

The guidelines of SLO regarding rhythmic synchronization and entrainment can be found in the guidelines regarding music-classes. The music learning guidelines of SLO are part of the curriculum frame of artistic orientation (SLO, 2019). SLO (2019) states that a music class mostly consists of social circumstances in which the children learn from group settings by imitating, comparing, observing and playing with others. Additionally, SLO (2019) confirms the previous literature research saying that children learn via embodied learning. Besides, SLO (2019) says that learning about music requires much concentration and listening skills since music can only be heard and not observed. And lastly, SLO (2019) defines that a characteristic of music education opposed to the other subjects of artistic orientation is that learning music is mostly reproduction like repetition, practicing and improving. Thus, SLO defines a music class as a social artistic orientation subject learning via reproduction and which requires high concentration and listening skills.

To specify the guidelines for rhythmic synchronization and entrainment, the table on the music learning guidelines provided by SLO (2019) is analyzed. This table is also given in Dutch in appendix 3. In this table, the competencies required for music per grade are shown. Regarding the rhythmical aspects, it states that in the first grades a child should learn to express the beat and tempo of music using bodily movements and he or she should be able to play simple rhythmic patterns in a group. In order to do this successfully, the child should be able to adjust the tempo and volume to those of the group and he or she should be able to start and stop simultaneously with the group by reacting to the leading gestures. During the years of primary education, the final goal to learn regarding rhythms is for the child to be able to independently play rhythmical patterns with correct timing in simultaneous and polyphonic situations and to be able to react to leading gestures. Thus, SLO is mainly focused on playing the correct rhythm in a group.

In order to broaden our knowledge on learning objectives and curricula, other curriculum developers can be compared to SLO. This could give us insights on how foreign developers compose their music curriculum and perhaps can be learned from those approaches, or can these approaches be incorporated in this project. The curricula provided

by the Ministry of Education of Singapore and the NCCA (National Council for Curriculum Assessment) in Ireland include music education which is a little more theoretically based. The NCCA is an organization supporting educational changes by advising the Minister for Education and Skills of Ireland on curriculum and assessment in their national education based on research, evaluation and foresight in existing educational institutes (National Council for Curriculum Assessment [NCCA], 2020). Just like the curriculum of the SLO, the Irish curriculum based on the advice of the NCCA and the curriculum of Singapore also include learning to express beat and rhythmic patterns and being able to adjust tempo using body movements, percussion or home-made instruments (Government of Ireland, 1999; Singapore Ministry of Education, 2016). In the first grades, the children start learning simple songs and through the years they learn to work with longer and more complex rhythms.

However, the curricula of Ireland and Singapore are not so much focused on group play, but rather on teaching recognizing and identifying rhythms based on symbols, words or existing songs and chants (Government of Ireland, 1999; Singapore Ministry of Education, 2016). The curriculum of the Government of Ireland (1999) states that in the first grades the children have to imitate, perform or listen to rhythms in words based on their syllables or using images representing the number and tempo of a clap or hit in a rhythm. Though the years the children have to learn to identify the rhythms of existing songs and note these rhythms using standard symbols for meter and rhythm. The curriculum of the Singapore Ministry of Education (2016) also states that the children should learn to recognize and identify the standard symbols for meter and rhythm. Additionally, the children learn terms to describe the (alternating) music tempo. Also, both the Irish and the Singaporean curriculum are much more focused on the improvisation and composition of own rhythmic pieces rather than the curriculum provided by SLO (Government of Ireland, 1999; Singapore Ministry of Education, 2016; SLO, 2019).

Not only these musical skills should be taught, but also certain additional skills that can be used besides being able to play a rhythm. For example, the SLO table (2019) tells us that the children should also learn to present their performance with conviction. This is comparable to the guidelines provided by the Irish curriculum (Government of Ireland, 1999). Additionally, the children should learn to listen to others and to provide others with constructive feedback and of course they should be able to receive feedback and use this feedback to improve their performances. This is not mentioned as part of the music curricula in either the Singaporean or the Irish curriculum. In short, for designing an instrument providing teachers with color-based feedback the SLO guidelines were taken into account, stating what children should learn regarding rhythmic synchronization and entrainment, yet, some additional guidelines provided by other curricula could also be taken into account.

2.4 Conclusion on the state of the art

Based on the literature, we can conclude that the feedback is most supportive and effective for the teacher during their music class if:

- The feedback gives insight on which of the children makes a mistake, at which moment and with which skill.
- The feedback shows individual differences.

- The feedback is easy to understand, natural and intuitive.
- The feedback does not add cognitive load for the teacher or the children.
- The feedback is unambiguous.
- The feedback is real-time.
- The feedback motivates children without distracting them from the class material.
- The feedback allows learning via sensory-motor symbolic understanding.

Regarding colors as a means of feedback it can be said that not so much (experimental) research has been done on how behavior is being influenced using colors. There is only theoretically based research about the meaning of colors or the emotional influence that colors might have. It is known that colors do trigger intuitive meanings and influence affects. From the literature it can be derived that these influences are developed from evolutionary and social perspectives.

Even though only little is known about the influence of colors on behavior, there is knowledge about visual feedback in general. The literature says that advantages of visual feedback are that it allows for a combination of auditory, visual and tactile stimuli. This combination contributes to an optimal learning process. Additionally, visual feedback can be given real-time, can incorporate embodied learning and is often motivational.

According to SLO, the Dutch curriculum developer organization, rhythmic synchronization and entrainment should be education in a group setting via embodied learning. Their final goal regarding rhythm in primary education is that the children are able to independently play rhythmical patterns with correct timing in both simultaneous and polyphonic situations and they are able to react to leading gestures of the teacher. Compared to foreign curriculum developers, SLO is more focused on practical skills in group settings, while the foreign curriculum developers are more focused on the theoretical aspects and more individual play. Both developers also focus on presentation and performance skills.

Chapter 3 – Ideation

In the ideation phase of the project, various ideas for a technological device were conceptualized. Already at the start of the ideation it was decided that the feedback given by the device should not be auditory, since auditory feedback would be very hard to hear while also listening to the class children making music. Furthermore, in previous researches of my critical observer textual feedback turned out to be ineffective, thus textual feedback was also not taken into account for designing a technological device. The first thing that came to mind that would work is visual feedback, thus the ideation was based on a technological device providing the teachers with visual feedback. Soon this type of visual feedback was specified as colors that should provide the teacher with feedback. Some ideas that evolved from the ideation were color projections on the table in different colors, shapes and sizes to indicate what a child is doing and maybe whether he or she is doing something correctly or not. Later on, an idea came up using a large LED circle that would light up in a certain color in front of the children. For both of the ideas, the children would use their hands to drum on the tables. Yet for these ideas, a large installation would have to be built, which is not favorable for educational settings if the only purpose of the installation is to teach music. Additionally, ideas for elaboration were often turned down very fast because they were found confusing,

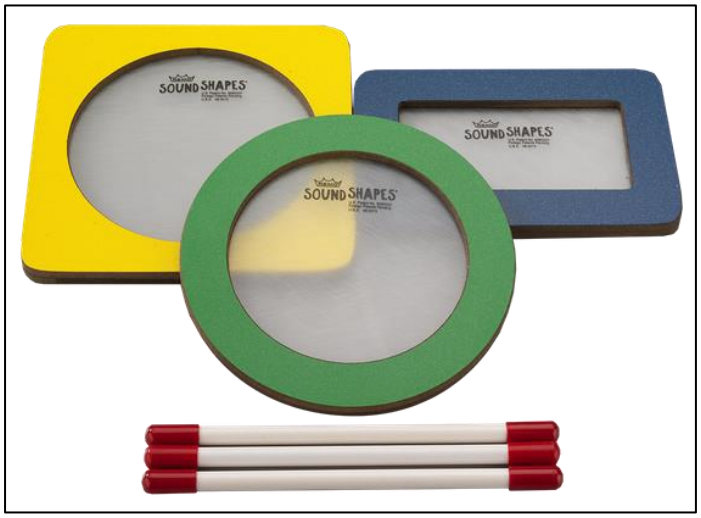
unclear or not supportive for the teacher. Therefore, the ideation continued. The idea evolving contained instruments that light up in a specific color that provides feedback to the teacher. This idea brought a lot of inspiration and ideas and therefore, the ideation continued as a brainstorming about the lightening instrument.

3.1 Ideation on lightening instruments

In order to come up with the final prototype idea, some ideation has been done about how to use lightening instruments. Firstly, some ideation has been done on which type of instrument should be used. The first idea was using maracas; however, this is a shakable instrument that does not have one clear beat but instead has two moments of rattles. This might confuse the children or the teacher and therefore rattling instruments or instruments using bells (e.g. maracas, tambourine, egg shakers, etc.) should not be used. Instead, an instrument should be used that allows hearing one beat per hit preferably with only one tone per instrument (e.g. Sound Shape, BoomWhacker, woodblock, etc.). For this project, the instrument that our prototype is based on is a sound shape (Figure 1). Sound shapes are flat pre-tuned drums that should be played using a stick. These Sound shapes exist in multiple sizes and shapes, but for this project, only the round shapes are being used. Yet, which instruments in what size or shape to use for the end product is still open for discussion. The choice could be based on price, easiness to store, preference of children, teachers or schools, etc.

Five general ideas regarding using color lightening instruments as feedback were created. In this section, an explanation of the ideas is given. For all of the ideas the technology behind the ideas has not been thought of yet, but in this stage only the idea on how to provide feedback in what situations has been developed.

Figure 1. Image of sound shapes

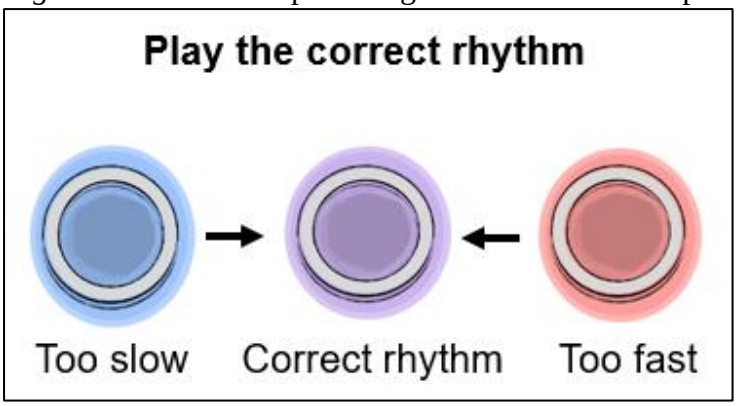


Sound Shapes: mini shape pack (n.d.) Retrieved from https://remo.com/products/product/sound-shapes-mini-shape-pack/

3.1.1 Play a rhythm with the correct tempo

The first idea that was created, is designed to provide the teacher with feedback that shows whether the children play a rhythm in the correct tempo. The instruments light up in one out of three colors. One of the colors indicates a correctly played rhythm and the other two point out a rhythm that is played either too fast or too slowly. An example representation is given in figure 2. In this figure the goal is to make the instrument light up in the correct color (in this case purple), thus the teacher knows that every child whose instrument is purple is playing the rhythm in the correct tempo. If the instrument is red, the teacher knows that the child is too fast. And if the instrument is blue, the child is too slow. This knowledge can be used by the teacher to correct the children. In this example, the colors blue, purple and red are used, yet, which colors should be used in the final idea is still open for discussion or investigation. The colors chosen should be clear and intuitive for the teacher to make the feedback understandable and supportive. Therefore, the idea is to make the middle color the color that is the mix of the 'outer' colors, because this should make the flow from slow to fast more natural. Additionally, the colors should not demotivate the children. However, which colors are most suitable is not known yet.
Example exercises that a teacher could use in a music class using this kind of feedback could be playing the same rhythm as the teacher, playing the rhythm of an existing song, playing the same rhythm as a classmate etc.

Figure 2. Instruments providing feedback on the tempo of the rhythm

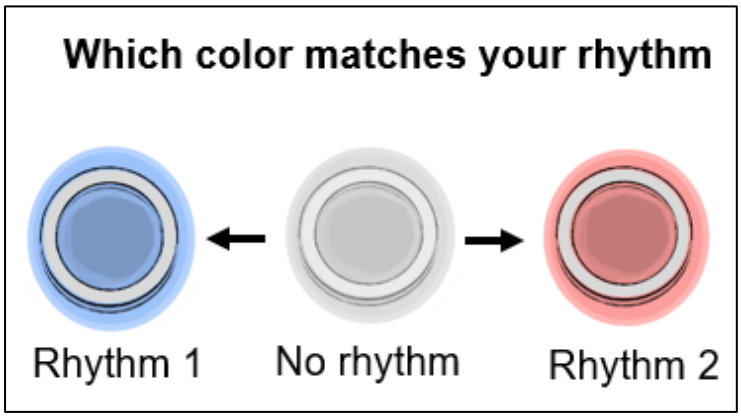


3.1.2 Colors matching a specific rhythm

A second idea was to use colors to represent a specific rhythm. This kind of feedback can be used to check if the children can keep playing their own rhythm without being distracted by the other children when they, for example, play a canon or in a polyphonic situation. A representative image is given in figure 3. If children play their rhythm correctly, their instrument turns the color of that rhythm. If the children play a rhythm that does not match one of the pre-set rhythms, the instrument remains white or uncolored. This way by means of the changing colors of the instrument the teacher can see if the children can keep playing their own rhythm and maybe provide extra support to the children in need of that. Example exercises that a teacher could use in a music class using this kind of feedback could be finding out which color represents the rhythm that is assigned to you, playing two different

rhythms alternately in a group circle, playing a canon rhythm, etc. Which colors are most clear or feel most intuitive for a teacher and should thus be used for this feedback is open for discussion or investigation to the effectiveness of the colors. The colors should not demotivate the children in the class and the colors of the different rhythms should be clearly distinguishable from one another.

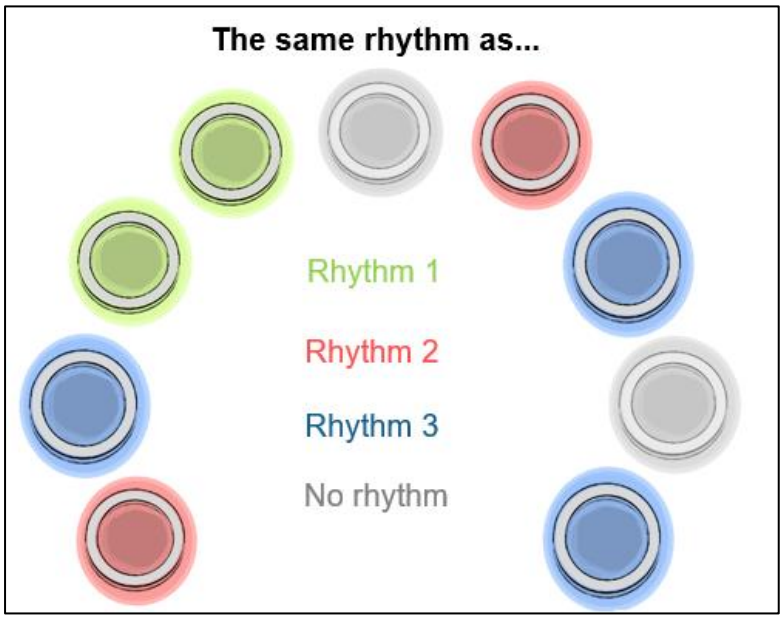
Figure 3. Instruments providing feedback on which rhythm is being played



3.1.3 Instruments with matching colors

This idea is about instruments that sync with each other. Instruments that play the same rhythm turn into the same color. An image demonstrating this idea is given in figure 4. If a child in a class plays a rhythm that no other child is playing, the instrument turns white or uncolored. The reason for this is that if the class consists of many children and each of the children plays a different rhythm, it is very hard to create enough colors to distinguish all of the different rhythms. Furthermore, the colors used to display the different rhythms should not demotivate the children and the different colors used should be clearly distinguishable from each other since else the feedback might not be clear. Which colors are to be used exactly is still open for discussion or for research to the effectiveness of certain colors. Exercises in a music class using these instruments could, for example, be finding a classmate who plays the same rhythm, play the same rhythm as the teacher, play the same rhythm as someone else, play a new rhythm (so one that no one else is playing) etc. Based on the colored feedback, the teacher can easily see who are capable of syncing with others and thus provide support to the children in need of that.

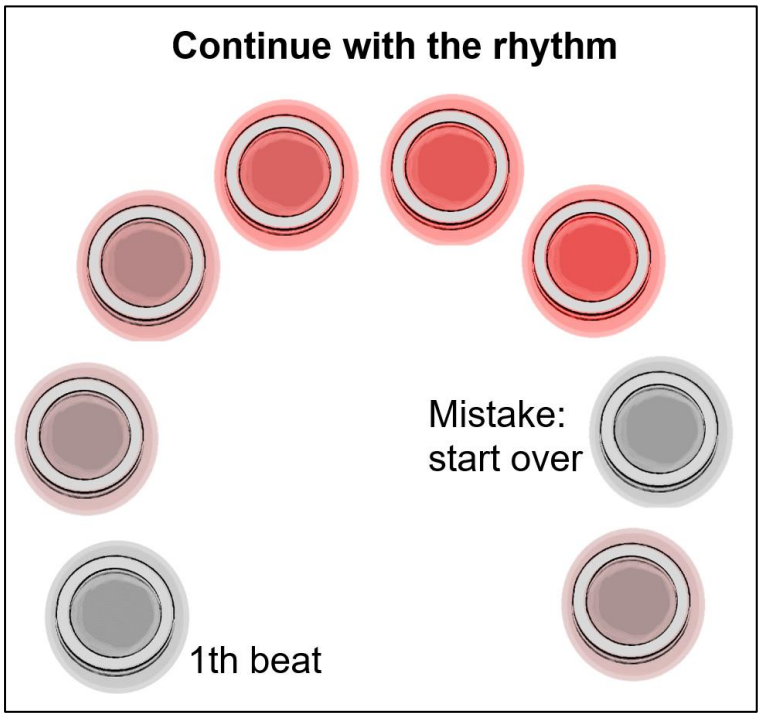
Figure 4. Instruments providing feedback on who are playing the same rhythm



3.1.4 Instruments with increasing brightness

This idea is based on a group exercise. In this exercise, the children are located in a circle and the goal is to have the whole group play one rhythm, but every beat of the rhythm is played in turns. Thus, in this exercise, the children have to focus on the rhythm that is played by the group and time their own turn with the correct timing of the rhythm that is being played. The instruments of the child who plays a specific beat of the rhythm lights up a bit brighter than the instrument of the previous child. A visualization of this is given in figure 5. If the brightest color is obtained then the instrument of the next child turns on with the same brightness. If a child timed his or her turn wrong, the instrument turns off and the rhythm has to start over. The color of the instruments remains the same for every child, with only a change in brightness. The reason for this is that multiple colors might cause confusion among the children or the teacher. Which color should be used is still open for discussion or for research to the effectiveness of the color. However, the color should not demotivate the children. Via this feedback, a teacher can easily see which of the children have trouble with the correct timing and thus the teacher knows which of the children needs some extra support with that.

Figure 5. Instruments providing feedback on playing a rhythm in terms



3.1.5 Partially lightened instruments

The last idea consists of a different way of providing feedback, namely only partly lightening up the instrument. A visualization of this can be seen in figure 6. This kind of visualization can be used to provide feedback on duration or amount. An exercise that can be used for this kind of visualization could be to play the same rhythm while maintaining the same tempo until the instrument is fully lightened. If the tempo of the rhythm played changes, the instrument turns off and the child has to start over again. By looking at how far each of the instruments is lightened, the teacher can see which of the children are good in keeping the correct tempo and which of the children is in need of extra help. Another exercise could be to think of new rhythmic patterns. Every time a new pattern is played, the instrument lightens up a bit more. This exercise could stimulate creativity, so the feedback shows which of the children are very creative regarding music. The color of the feedback is still open for discussion or for research to the effectiveness of the color. Yet, the color should not demotivate the children.

Figure 6. Instruments providing feedback in parts of the instrument

3.2 Conclusion on ideation

To conclude, during the ideation multiple ideas were discussed. Eventually it was decided to use visual feedback to support teachers during their music class. The visual feedback is incorporated into lightening instruments using colors as a means of feedback. Additionally, five ideas on how this type of feedback can be used were created. The first idea is ‘play a rhythm with the correct tempo’ in which the lightening instruments provide feedback on which of the children plays a rhythm too fast, too slowly or at the correct tempo. The second idea is ‘colors matching a specific rhythm’ in which the colors of the instruments turn into the colors of a specific rhythm if that specific rhythm is played. The third idea is ‘instruments with matching colors’ in which instrument colors turn into the same color when the same rhythm is being played on those instruments. The fourth idea is ‘instruments with increasing brightness’ in which the class children together have to play a rhythm in turns, and for each correct hit, the instruments light up a bit brighter than the previous instrument. And the last idea is ‘partially lightened instruments’ in which the feedback represents time or an amount (e.g. of original rhythms played).

These ideas are interesting, yet, in this project only the ideas of ‘play a rhythm with the correct tempo’, ‘instruments with matching colors’ and ‘instruments with increasing brightness’ are further investigated. The other ideas could be investigated in further research.

Chapter 4 – Requirements and specification

For this project, a technological device should be designed to support primary school teachers while they are teaching music. The color-lightening instruments turned out to be the most favorable idea in the ideation phase. Yet, both the client and the literature suggest and require certain aspects that should be included in the device to be supportive for the teachers. In this chapter, the requirements of the project are enlisted, and ranked in order of importance. This

is done according to the MoSCoW method. This method is a technique used to order requirements based on priority from ‘needed to make the product work and achieve the main goal’ to ‘least important or not necessarily relevant for the current research’.

The idea includes actual instruments providing feedback on the rhythmic skills of primary school children that the teacher can use to support the children. However, due to a lack of technology, the final idea cannot yet be built by myself within this limited time. Additionally, due to COVID-19 there are a lot of limitations for the user testing. Therefore, the prototype is a simulation of how these instruments can be used in class showing what feedback is given by these instruments. This prototype can be tested using videos, but thus only is a representation of the equipment instead of the final device.

Must have:

- The prototype represents equipment that is able to show individual differences between at least ten children.
- The prototype represents equipment that is supportive for a primary teacher while teaching rhythmic synchronization and entrainment to the extent that:
    - Insight is given on which of the class children require extra support.
    - Insight is given on what aspect of rhythmic synchronization and entrainments are not yet mastered by the children.
    - Insight is given on at which moment the class children face these difficulties.

Should have:

- The prototype represents equipment that is able to involve children in a music class without unnecessary distractions from the class material.
- The prototype represents equipment that does not substantially increase the cognitive load of either the teacher or the children.

Could have:

- The prototype represents equipment that is able to motivate the class children.
- The prototype represents equipment that enhances the learning process of the children.
- The prototype represents equipment that allows teachers to shape their own music class using the equipment.
- The prototype represents equipment that is self-learning for the children
- The prototype represents equipment that provides real-time feedback.
- The prototype represents equipment that provides easy, natural and intuitive feedback.
- The prototype represents equipment that allows or even stimulates learning in a social group setting.
- The prototype represents equipment that follows the guidelines of SLO and or other curriculum developers.

Won't have:

- The prototype will not be a lightening instrument that can be used in class in this project.
- The prototype will not focus on aspects other than rhythmic synchronization and entrainment in this project.
- The prototype will not focus on other (body) instruments than the Sound shape in this project.

Based on these requirements we specified what the prototype should do or look like. As mentioned earlier in this chapter, the prototype should be a simulation, representing a class of primary school children. The prototype should show at least ten children each holding their own lightening instruments. The instruments should be able to light up in different colors and brightness levels so as to visualize some of the ideas given in the ideation section.

The first visualization that had to be built is based on idea 3.1.1 (playing a rhythm in the correct tempo). For this idea, two scenarios had to be built using different colors. The reason for this was that we wanted to compare different colors in order to find out which colors are preferable. The first scenario should use the colors blue, purple and red. In this case the color representing the children playing the correct rhythm is purple. In the second scenario, the colors used are yellow, green and blue in which green represents the children playing a correct rhythm. These two color-sets are chosen because both sets consist of two primary colors and their mix. A third option would have been to use yellow, orange and red, but since those colors are hard to distinguish this option was abandoned. In both cases, instruments' colors turn randomly into the colors representing a too fast or a too slow rhythm.
The second visualization that should be built is idea 3.1.3 (instruments with matching colors). For this idea, we set up again two different scenarios have to compare the colors. For both scenarios, the color white was to be used to indicate a child playing an original rhythm. Furthermore, one scenario should include the colors red, green and blue as matching colors and the other scenario should use the colors yellow, purple and turquoise. These color-sets are chosen because they consist of the primary colors of light and the mixes of these colors. This way a broad variety of colors can be tested on distinguishability of the colors. In both cases, instruments' colors randomly synchronize colors or turn white. Additionally, we took into account that there are constantly at least two instruments of every color (except for the color white). This is because if a child is the only one with an instrument in that color, he or she is not playing the same rhythm as another child and thus the instrument is supposed to be white. The last idea that should be visualized is idea 3.1.4 (instruments with increasing brightness). For this idea, the instruments light up in turns (following the circle). Every time an instrument lights up it should be a bit brighter than the previous instrument. Randomly, all instruments should be turned off, and the instrument that would have been next starts flickering to simulate a 'mistake'. Thereafter, the instruments start lightening up with increasing brightness again, starting with the flickering instrument. The last thing that should be built is a set-up in which each of the instruments lights up in a different color so the differences in colors can be seen. At least the colors blue, green, red, yellow, purple, turquoise, orange and white should be shown in the prototype. If more variations of these colors are possible, it would be even better.

Chapter 5 – Realization

In this chapter, an explanation is given of the building process of the prototypes and their evaluation. First, the design of the prototype is explained. Second, the hardware iterative process is described ending with the final hardware setup. Thereafter, the codes implementing the ideas of the iteration into the prototype are explained. Then the user test is explained, including participants, procedure and materials, results and discussion with improvements. Last, the findings of the realization are concluded.

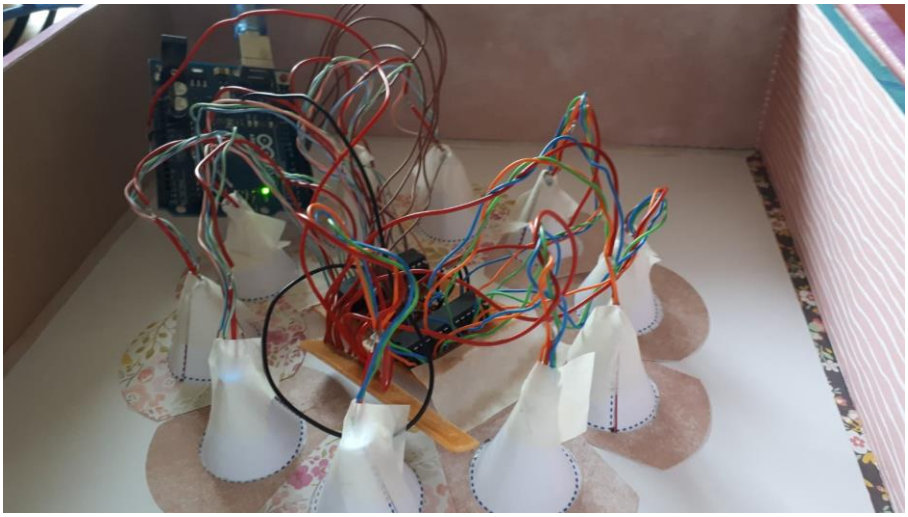
5.1 Prototype design

For the design of the prototype, the goal was to simulate a classroom with a minimum of ten children. Therefore, the design is built in a paper box with ten small children located in a circle. Each of the children has his or her own drum and underneath each of the drums, the LEDs are attached. An image of the box is given in Figure 7. The details can be found when looking to the colors of the circles and the colors of the shirts of the children. They are the same color for each of the children. The reason for this is to allow the teacher to easily recognize which of the instruments belongs to which child. The children on the box are located rather close to each other compared to a real-life class. And children in a real class are actually holding the instrument while on the box, the children are located next to the drums. Thus, I think that in a real-life class it is easier to recognize which instrument belongs to which student. Additionally, the children on the box do not touch the drums with their hands. The reason for this is that we chose to focus on the sound-shape as an instrument, and the sound-shape should be played using a stick instead of using hands.

In figure 8, an image of the inside of the prototype can be seen. It can be seen that the hardware is placed inside the box. The LEDs are attached inside a cone underneath a drum. Each of the cones has an inside layer made out of aluminum foil. The purpose of the aluminum foil is to distribute the light over the complete area of the drums. If the aluminum foil were not added, only a small circle of light would be displayed on the drums.

Figure 7. Image of the proto-type design

Figure 8. Image of inside of the proto-type design



5.2 Hardware building

In order to build the simulation explained in the prototype design (5.1, see figure 9), a hardware setup is needed that includes and controls ten RGB-LEDs (Red, Green & Blue Light Emitting Diodes) with the possibility of adjusting color and brightness of each of the LEDs individually. These 10 RGB-LEDs are being controlled using an Arduino Uno or the Wemos d1 mini. Both computer chips run using Arduino software. These chips have only a limited number of in/output pins, yet in order to control 10 RGB-LEDs, at least 30 in/output pins are needed. Therefore, experiments and tests have been done to which computer chip could be used best for the simulation and which other components are needed. Several iterations using different components and hardware setups are explained in this section.

5.2.1 Controlling 10 RGB LEDs via WIFI connection

For the first iteration, the Wemos d1 mini is used to control ten RGB-LEDs via WIFI. The Wemos d1 mini can control three RGB-LEDs in total, this means that one Wemos d1 mini on its own is not sufficient to control all ten LEDs. A characteristic of the Wemos is that it is capable of communicating via WIFI. Therefore, in my setup, I used several of these Wemos computers that communicated with each other via WIFI in order to control all the LEDs. The connection was built in three steps. Firstly, two Wemos computers were connected to each other. One of the two was connected to the LEDs while the other was connected to a button that could turn on the LEDs of the other Wemos. Secondly, two Wemos devices were connected to each other, both controlling LEDs. And lastly, a connection between three Wemos devices was built. An explanation on each of the steps is given below.

5.2.1.1 WIFI connection between two Wemos devices: one button and three LEDs

In this step, the goal is to make the communication work between the two Wemos computers. We wanted to achieve that the LEDs connected to one Wemos can be turned on or off by pressing the button connected to the other Wemos. A picture of the hardware setting is given in figure 9. Also, a fritzing (hardware schematic) made via the software program ‘fritzing’ is given in figure 10 showing how the RGB-LEDs are connected to the Wemos. In order for the connection to work, one of the Wemos devices is the server and the other Wemos device is the client. The server is handling all the requests sent by a client, and thus the client is sending the request to the server. For each of the requests, the server sends a response to the client who sent the request. Once this connection succeeded, the button of the second Wemos is replaced by three RGB-LEDs.

Figure 9. Hardware picture of three RGB-LEDs connected to a Wemos d1 mini that are controlled by a button that is connected to a second Wemos d1 mini

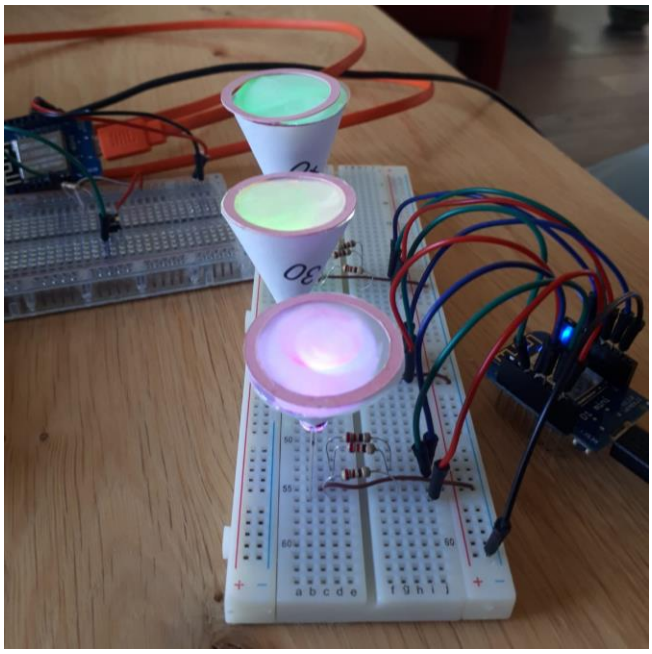
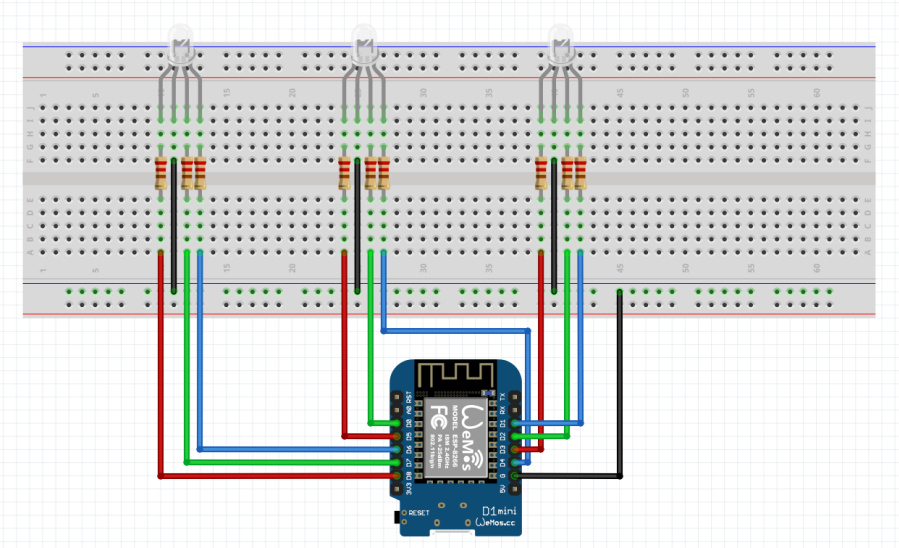


Figure 10. Hardware fritzing of three RGB-LEDs connected to a Wemos d1 mini (Common cathode RGB-LEDs)



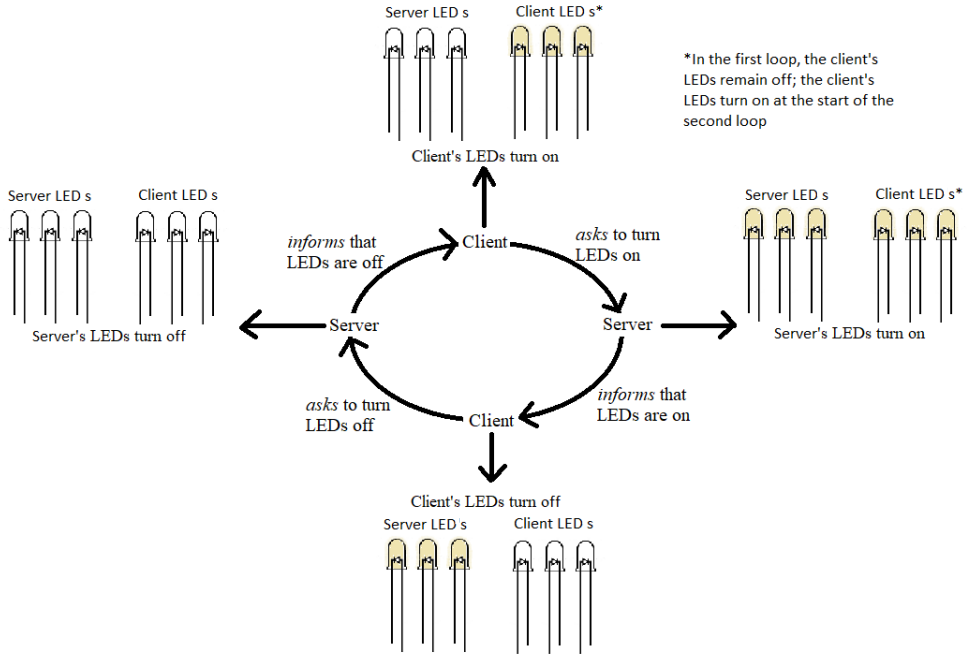
5.2.1.2 WIFI connection between two Wemos devices: six LEDs

In this step, the goal is to create a communication loop between the two Wemos devices. In this loop, the Wemos devices communicate with each other via WIFI sending messages to light up their LEDs in turns, alternating between the two devices. An explanation on how this communication loop works is given in subsection ‘communication protocol between two Wemos devices’. Both Wemos devices are connected to RGB-LEDs (see figure 10) and a code is created to make the communication between these devices work. Still, one of the devices is the server and the other one is the client. The code for the server Wemos is given in appendix 4a and the code for the client Wemos is given in appendix 4b.

Communication protocol between two Wemos devices

The loop starts with the client sending a request to the server. With this request, the client asks the server to turn its lights on. As a response, the server informs the client that the server's LEDs are on. Once this response has been read by the client, the client turns off its LEDs (in the first round of the loop, the LEDs are off already). Once the LEDs of the client are off, the client sends a request to the server to turn off its LEDs as well. This request is handled by the server and as a response it lets the client know that its LEDs are off. When the client reads this response, it turns its own LEDs on. Once its LEDs are on, the loop starts over again with the client sending a request to the server to turn its LEDs on. A visualization of this communication loop is given in figure 11. This communication had only a little delay and thus worked quite smoothly.

Figure 11. visualization of communication loop between two Wemos devices



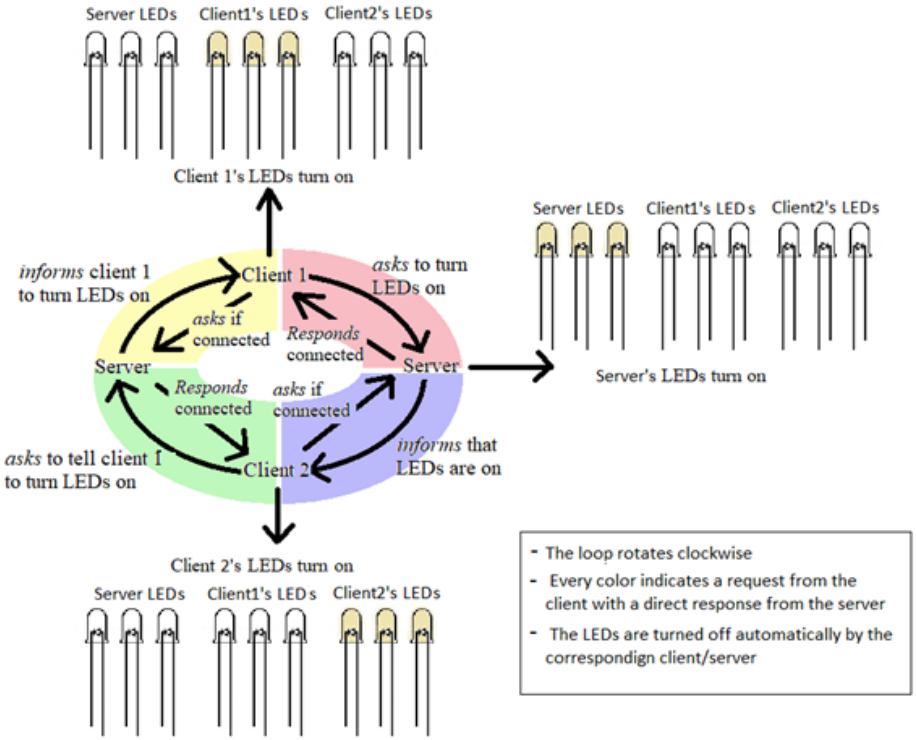
5.2.1.3 WIFI connection between three Wemos devices

The communication between two Wemos devices worked quite well, however, two Wemos devices can only control six LEDs. Therefore, in this step, a third Wemos is added to the connection circuit to be able to control three additional RGB-LEDs. These RGB-LEDS are connected to the Wemos as constructed in figure 10 and is the second client within the WIFI communication. Comparable to the WIFI connection between two Wemos devices, a code is created to make a loop between the devices to turn the lights on and off in turns. However, in this loop, the lights are automatically turned off by the corresponding Wemos instead of receiving a command from another device. Both clients in this circuit have to communicate via the server and cannot communicate directly with one another, the result being that the loop becomes more complicated compared to the loop consisting of only two Wemos devices.

Communication protocol between three Wemos devices

In this communication loop, both the clients have to send requests to the server asking whether their light should be turned on or off and both clients have to update the server about whether their lights are on or off. Using Booleans, the server informs the clients which should turn on its lights. Also, the server has to make sure that the requests are only sent to the clients if they are connected to the server, because if they are not connected, they do not receive the response. Besides, the response given by the server should indicate which of the devices should turn their lights on or off and the clients should also properly read this response. In this loop, the first step is that client2 asks the server to turn on its LEDs. Thereafter, the server turns on its lights and informs client1 that its lights can be turned on. Then, client1 turns on its LEDs and sends a request to the server telling the server that client2 can turn on its lights. When the server reads this request, he informs client2 that his LEDs can be turned on. After that, client2 turns on its LEDs and the loop starts over again with client 2 asking the server to turn on its LEDs. A visualization of this communication loop can be found in figure 12. Additionally, the code of the server can be found in appendix 4c, the code of client1 is given in appendix 4d and the code of client2 can be seen in appendix 4e.

Figure 12. Visualization of communication loop between two Wemos devices



The WIFI loop worked fine and the devices turned on their LEDs one after the other, however, there was a delay of approximately three seconds in this communication loop. This means that when the lights of one Wemos turn off, it takes approximately three seconds before the lights of the next Wemos are turned on. This is a problem since the LEDs should react smoothly one after the other without this much delay in order for the simulation to be

representative for the class setting using the instrument. We are not sure why the delay is this long. A possibility could be that the loop is too complex to work properly, or that the WIFI is too slow, yet, we did not know how improve this system. Additionally, only nine RGB-LEDs could be controlled using this setup, while ten RGB-LEDs are required. This implies that another Wemos device should be connected to be able to control all of the required LEDs, which would result in an even longer delay. Due to these reasons, WIFI communication between multiple Wemos devices does not suffice for my prototype and thus we switch to using a different type of circuit, using a 74HC4067 Multiplexer.

5.2.2 Controlling 10 RGB LEDs via multiplexing

For the second iteration, our aim was to find a hardware setup that could control ten RGB-LEDs without a long delay. To achieve this, we wanted to use a chip that is able to expand the number of in/output pins, therefor, a Multiplexer 74HC4067 is used. A multiplexer is a chip that is capable of sending a current from an output pin of a computer device like Arduino to any one of the output pins (in this case 16) of the multiplexer chip. This means that an additional 16 pins can be used and thus five RGB-LEDs can be controlled using this chip. In order for this multiplexer to work, it has to be connected to one analog output pin, which is the pin sending the signal to the LEDs and to 4 (digital) output pins which regulate to which of the 16 pins the signal should be sent (see figure 13). The analog pin is needed since the LEDs should also be able to vary in brightness, thus multiple values (analog output) are needed instead of only two values (digital output). The four digital pins are connected to the control pins of the multiplexer (s0, s1, s2, s3) and work by setting certain control pins high and other control pins low. The combination of control pins that have a current flow decides via a binary equivalent which of the output pins are used. In figure 14, a truth table is given that shows which control pin combination selects which channel.

Since five LEDs is only half the number of the RGB-LEDs required, two multiplexers were used, thus a total of ten RGB-LEDs can be controlled. A picture of the hardware setup is given in figure 15 and the fritzing of the same setup is given in figure 16. A code was created to test how the multiplexer worked by turning certain pins on and others off. In appendix 5, a code is given that was used to turn on all of the 15 output pins that were used. However, while testing was discovered that the multiplexer is not capable of sending signals to different LEDs simultaneously. The reason for this is that the multiplexer works via a binary equivalent, which means that if two signals are sent simultaneously (e.g. the signal for pin 1 and for pin 4) a third signal is also read by the multiplexer (in this case for pin 5). This means that the multiplexer alone is not the ideal component to be used, since for the class simulation it is necessary that each of the pins can be controlled individually and simultaneously without influencing other pins as well. Therefore, we switch to using a different type of circuit again, this time a TLC5940 Led Driver.

Figure 13. Input connections of the multiplexer 74HC4067

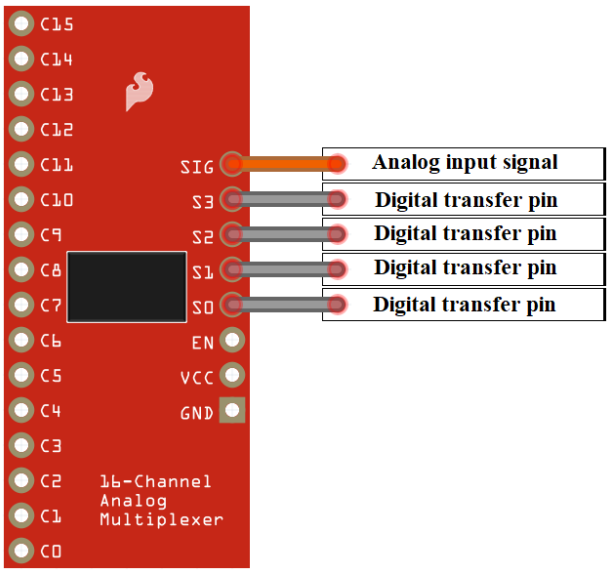


Figure 14. Truth table of the multiplexer 74HC4067

TRUTH TABLE

S0	S1	S2	S3	$\overline{E}$	SELECTED CHANNEL
X	X	X	X	1	None
0	0	0	0	0	0
1	0	0	0	0	1
0	1	0	0	0	2
1	1	0	0	0	3
0	0	1	0	0	4
1	0	1	0	0	5
0	1	1	0	0	6
1	1	1	0	0	7
0	0	0	1	0	8
1	0	0	1	0	9
0	1	0	1	0	10
1	1	0	1	0	11
0	0	1	1	0	12
1	0	1	1	0	13
0	1	1	1	0	14
1	1	1	1	0	15

H= High Level
L= Low Level
X= Don't Care

Step 2: truth table (n.d.) Retrieved from https://www.instructables.com/id/Tutorial-74HC4067-16-Channel-Analog-Multiplexer-De/

Figure 15. Hardware picture of ten RGB-LEDs controlled via an Arduino Uno and two 74HC4067 Multiplexers

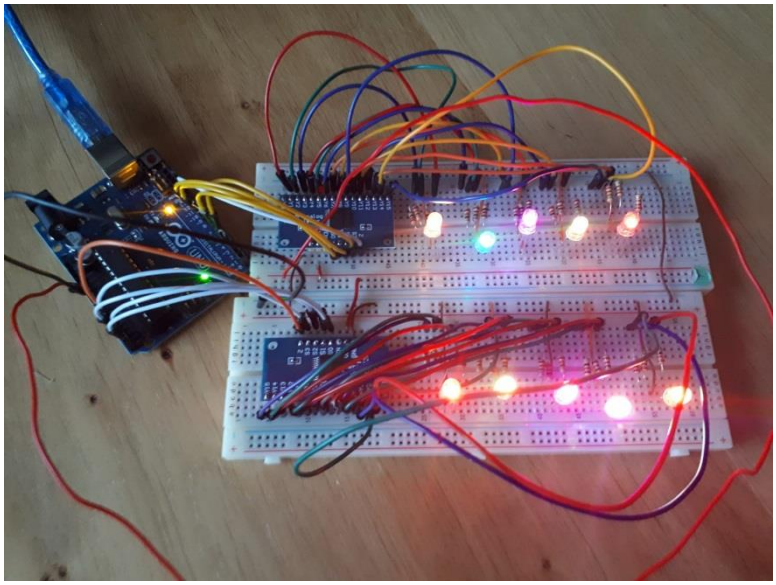
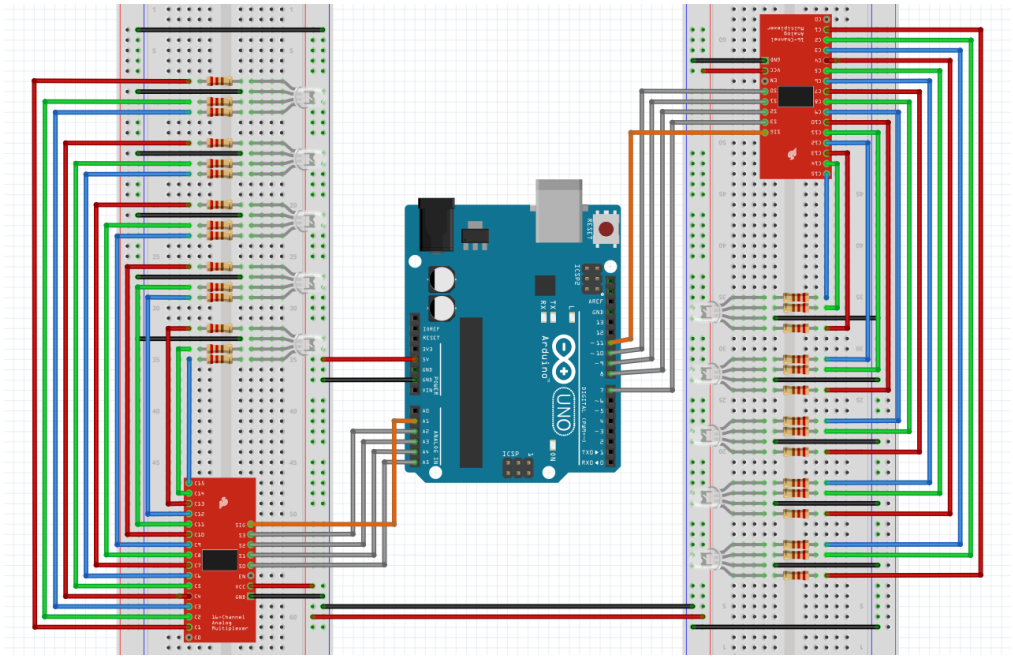


Figure 16. Hardware fritzing of ten RGB-LEDs controlled via an Arduino Uno and two 74HC4067 Multiplexers (Common cathode RGB-LEDs)



5.2.3 Controlling 10 RGB LEDs individually and simultaneously using a LED driver

For the final iteration, the goal is to find a hardware setup that is able to control all ten RGB-LEDs individually and simultaneously varying in color and brightness, without a long delay. For this the TLC5940 LED driver is used. The TLC5940 is a constant-current sink LED driver with 16 individually controllable channels. This means that five of the RGB-LEDs can be controlled individually and simultaneously varying in color and brightness. To control all 10 RGB-LEDs, two chips are needed. A characteristic of these chips is that they can be daisy chained endlessly, meaning that the output pins can easily be expanded while only requiring limited output pins of the Arduino. A picture of the hardware setup is given in figure 17 and the fritzing of the hardware is given in figure 18. A code was created to control the RGB-LEDs. The code created is given in appendix 6. Everything using the TLC5940 worked, and thus this hardware setup is used for the prototype. An image of the soldered hardware can be seen in figure 19. Multiple variations of color combinations of the LEDs are coded. First of all, the three ideas of the ideation are coded as explained in the specification (playing a rhythm in the correct tempo, instruments with matching colors and instruments with increasing brightness; chapter 4). Secondly, a code is made that lights up the instruments in a different color as is also explained in the specification (chapter 4). And lastly, a code is created in which all of the instruments turn white to check whether all the connections are still working.

Figure 17. Hardware pictures of RGB-LEDs connected to (a) TLC5940 LED driver(s) and an Arduino Uno

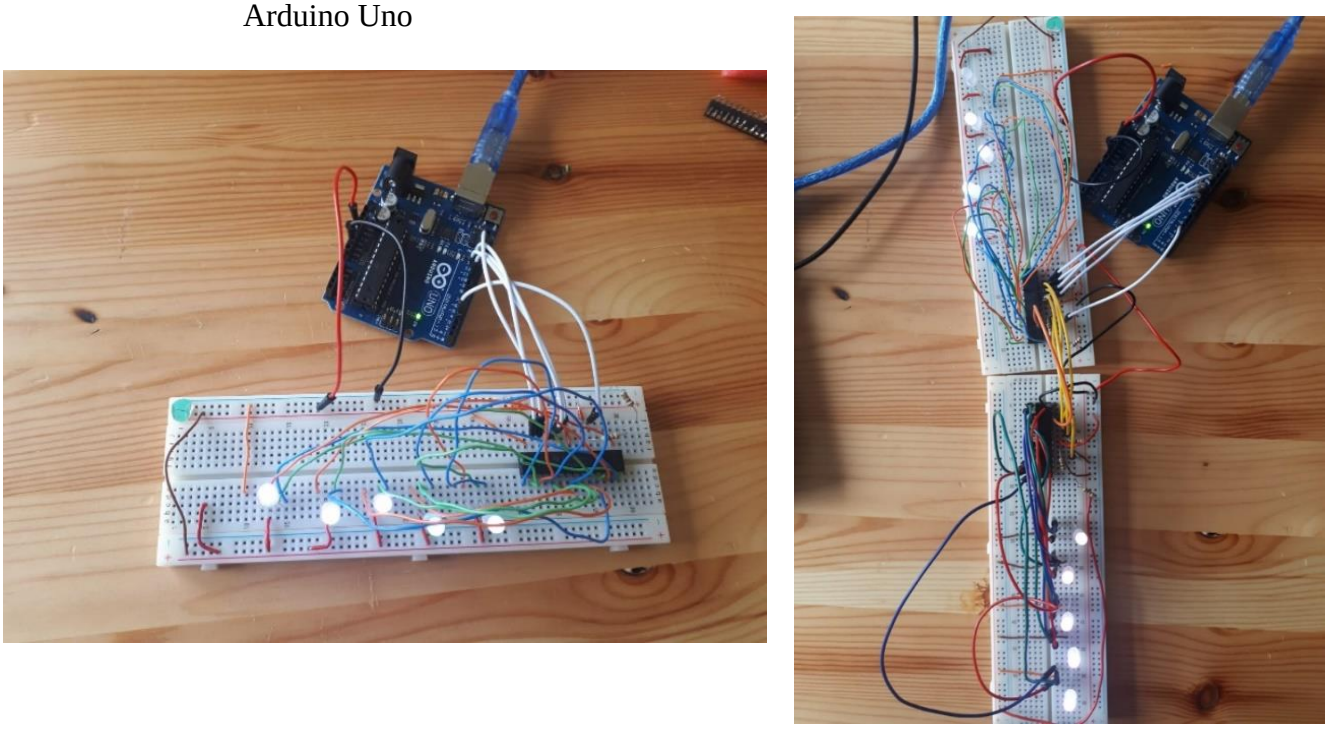


Figure 18. Hardware fritzing of ten RGB-LEDs controlled via an Arduino Uno and two TLC5940 LED drivers (Common anode RGB-LEDs)

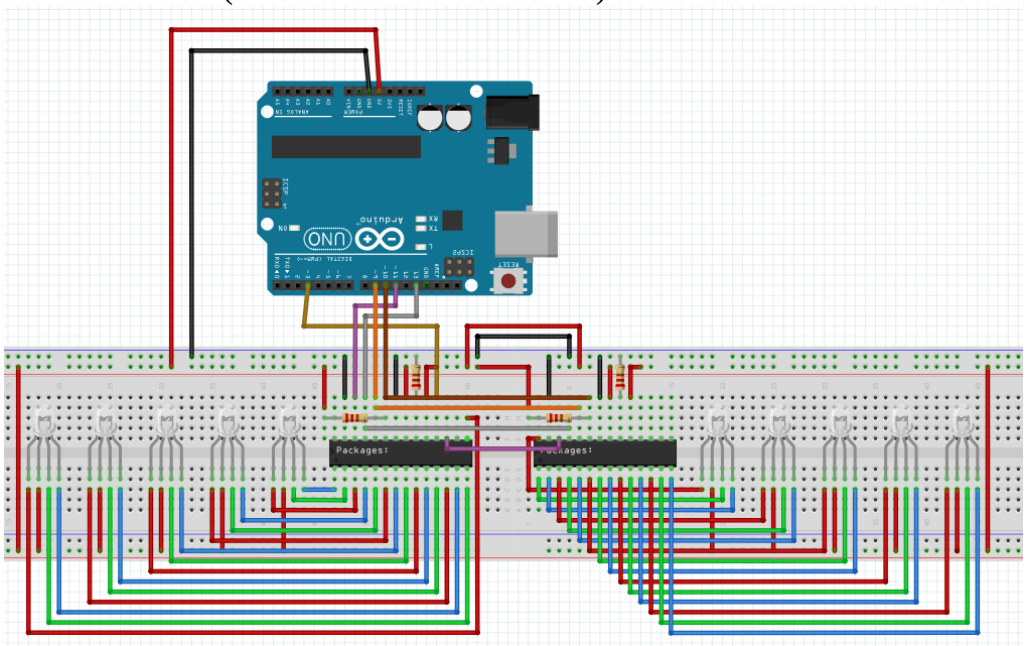
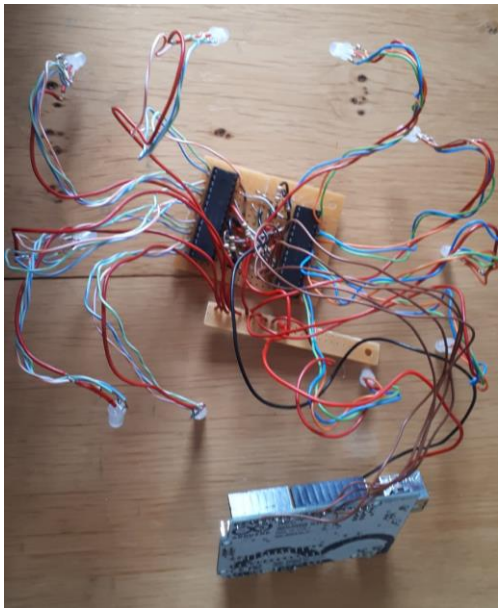
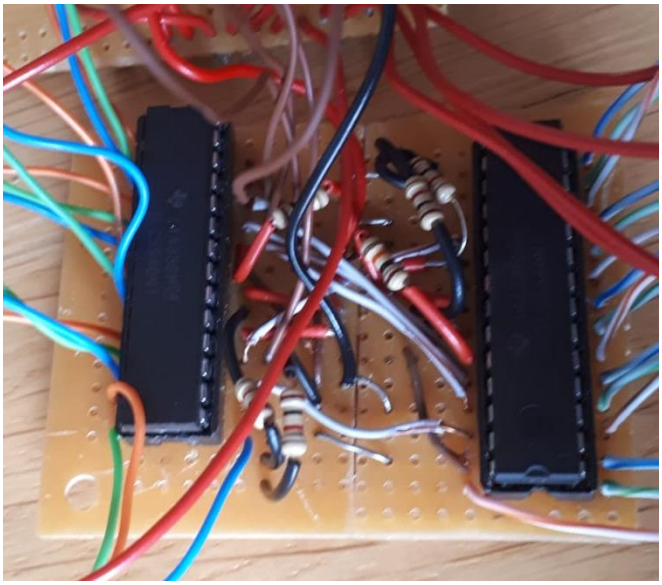


Figure 19. Final soldered hardware of ten RGB-LEDs controlled via an Arduino Uno and two TLC5940 LED drivers





5.3 Explanation of hardware-codes

5.3.1 Code for 'instruments with increasing brightness'

In this code, a simulation is made that visualizes the idea of 'instruments with increasing brightness' explained in ideation idea 3.1.4. One rhythm has to be played, but children play the rhythm together in turns, thus the children need to pay attention to when it is their turn to hit the Sound shape. The LEDs all start in an initial state where the lights are turned off and in turns the LEDs start to light up each with a little increase in brightness. The simulation displays a child making a mistake by turning off all the LEDs and the LED that should have

been next starts flickering and is the first LED that lights up for the next round. Which of the simulated children is the child making a mistake is coded using a random function, thus ensuring that the ‘mistake’ is not made by the same child(ren). An image of this code is given in figure 20.

Figure 20. Image of brightness code result

5.3.2 Code for ‘playing a rhythm in the correct tempo’

In this code, a simulation is created that visualizes the idea of ‘playing a rhythm in the correct tempo’ as explained in 3.1.1. The idea of this feedback is that the whole class plays the same rhythm simultaneously. If a child plays a rhythm either too fast or too slowly, the instrument changes color. It has not been decided yet which color should represent a child playing too slowly or too fast. Two different codes were created visualizing this idea using different colors, to discuss the color preferences in a user test. In the first scenario, all instruments start in the color green and some of the instruments turn either blue or yellow to represent children playing a rhythm either too fast or too slowly. In the second scenario, all instruments start purple and some of the instruments turn blue or red to represent children playing either too fast or too slowly. Which instruments change colors is programmed using a random function to ensure that a mistake is made by different children. To simulate children that play the rhythm correctly, the instruments turn green in the first scenario and purple in the second. An image of this is given in figure 21.

Figure 21. Images of tempo codes results


5.3.3 Code for ‘instruments with matching colors’

In this code, a simulation is built visualizing the idea of ‘instruments with matching colors’ as explained in 3.1.3. The idea is that instruments that are the same color, play the same rhythms and the white ones represent an original rhythm. Comparable to the ‘playing a rhythm in the correct tempo’ code, two different scenarios were programmed just to discuss the color preferences in a user test. In both scenarios, the LEDs light up in groups of the same color. In the first scenario, these groups are blue, red and green and in the second scenario these groups are aqua, yellow and purple. In both cases one of the instruments turns white. An image of this code is given in figure 22.

Figure 22. Images of sync codes results


5.3.4 Code lighting up the instruments in different colors

This code is created to light up all the LEDs on in a different color. The reason why this is built is to see which colors are distinguishable from each other and to discuss color preferences in a user test. An image of this is given in figure 23.

Figure 23. Image of multicolor code results

5.3.5 Code turning each instrument white

This code is programmed to be able to do a check to see if all the connections and LEDs are still properly working. The code turns all the LEDs on in a white color. This way it can easily be seen if one of the connections is broken, since if something is not working properly, the LEDs will either not light up or light up in a different color than white. An image of this code can be seen in figure 24.

Figure 24. Image of white code results

5.4 User tests

In order to find out whether this kind of feedback is clear and would be effective, a user test was done with pre-service teachers. The goal of the test was to find out what aspects are useful and which aspects could still be improved. Also, some new insights and opinions can be collected via the user tests. The knowledge gathered from the user-tests can be used to improve the prototype.

5.4.1 Participants

The test-participants were assembled via my critical observer. For his research, he currently works with a focus group consisting of several PABO students (Teacher academy). He asked those students to participate in my user test. In total, 5 pre-service teachers were willing to participate. All of the participants were female and third years PABO students and their mean age was 21.4 years old.

5.4.2 Procedure and materials

The user tests were online semi-structured interviews in which the prototype was discussed following the questions formulated in the blank interview form given in appendix 7a. Prior to the user test, the participants had to read the information brochure (see appendix 7b) written for the research of my critical observer and the participants had to sign the consent form given in appendix 7c. Thereafter, the participants contacted me to make an appointment for the interview. Via e-mail, the participants received an invitation for an online 'Zoom' meeting and the videos of my proto-type simulating a class of children using the lightening instruments. These videos include all of the codes described in 5.I3, except for the 'white'-code, and these were the videos to be discussed during the interview. The videos used were filmed with a camera that was able to film with proper quality to see the colors of the prototype. Since cameras often have difficulties filming light, these videos had to be edited to improve the lightening and the observability of the color differences. This editing had been done via the software program 'VSDC video editor'. Additionally, an audio had been made to represent what the class should approximately sound like. This fragment was edited in the software program 'Audacity'. At the arranged date, the participants joined the 'Zoom' meeting. Firstly, an introduction about myself and an explanation of the goal of the interview was given. Thereafter the interview itself started. The participants could watch the videos again during the interview to have the videos freshly in mind. After going through all of the videos and questions, the participants were thanked and left the meeting.

5.4.3 Results

5.4.3.1 Feedback on the 'instruments with increasing brightness' video

The first video discussed was the brightness video, in which the LEDs light up in turns with increasing brightness. All of the students were asked what they thought the feedback meant, without giving them an explanation about it. Three out of the five participants recognized the flickering instrument belonged to the student hitting the Sound shape at an incorrect timing. Only one of the participants mentioned having no idea what it could mean without

explanation and another participant mentioned that the rhythm was played better if the light was brighter. Also, two of the participants thought that the LEDs were indicating when the children should hit the Sound shape instead of reading the lights as feedback based on how the students played the Sound shape. Three of the participants also mentioned that they heard the students play more loudly or more softly, but they were not sure what the feedback of the LEDs had to do with that. After hearing the explanation of what the LEDs are supposed to indicate, all of the participants said that the feedback was clear. All of the participants said that this feedback is motivational and fun for the students, however, the instruments could also cause demotivation, frustration or group-pressure in case one of the children hits the Sound shape at an incorrect timing. The participants also offered a solution on how they would handle this in their class. One of the participants said that each time that the class has to start over, she would give the start turn to another child. Another participant said that she would start practicing this exercise without turning the LEDs on the instruments on. And the last solution was to avoid turning the LEDs off when a child has the wrong timing, but instead light up the LED at the same brightness level as the previous instrument and include a goal for the children to achieve. This could be, for example, that all the instruments turn green once the goal has been achieved. Another thing that was mentioned is that this kind of exercise could best be done in a class of experienced children, since otherwise the instruments keep turning off if none of the children is capable to hit the Sound shape with the right timing. And lastly, one of the participants mentioned as an additional idea that this set up could also be used to practice dynamics.

5.4.3.2 Feedback on the ‘playing a rhythm in the correct tempo’ video

Secondly, the tempo videos were discussed in which the instruments indicate whether the children play a rhythm at the right tempo. Again, the students were asked what they thought the feedback meant before they received an explanation. Only one of the participants was confused and did not know what the feedback meant. The other four, however, all said that in the one video the purple rhythm was correct and in the other video the green rhythm was correct and they all mentioned that a child played a wrong rhythm when their instrument changed color. However, what went wrong for which color was not clear. The students were asked what meaning they would give to which changing color (so blue and red for one video and yellow and blue for the other video). In case of the purple video, four participants said that they would use blue for children who play too slowly and red for students who play too fast. Only one participant would use the colors the other way round. In the green video, three participants said that they would use yellow for the students who play too slowly and blue for the students who play too fast. One participant would use the colors the other way round and one participant did not discuss her preference for the colors definitions of the green video. Furthermore, the participants were asked if they preferred the colors of the purple or the green video. Three participants argued that the purple video had their preference, since the colors are better differentiable from each other and two participants argued that the green one had their preference for the reason that the green one was more positive because green is often associated with good. Another question asked was whether the participants thought that the lightening instruments would also be supportive for a class of approximately thirty

children. Three participants mentioned that it would still be supportive since the children also get a chance to improve their own rhythm due to the feedback given. Thus, even though the teacher might not be able to help each of the children, the feedback would still support their class. Also, one of the students mentioned that if a lot of children play the rhythm at a wrong tempo, it would be best to stop and start over with the complete class instead of correcting the individuals. Two participants mentioned that they preferred to work in small groups, however, they also had that preference if the instruments would not be used. When asked how the children would react to this kind of feedback, four of the participants mentioned that it would be much fun and very motivational for the children to use lightening instruments, especially since they have the goal to keep the color of their instrument the correct color. On the other hand, two students mentioned that there should be special attention for children with performance anxiety, group-pressure, failure frustrations etc. An additional exercise that could be executed using these instruments and mentioned by one of the participants is to 'find out what the colors mean'. In this exercise, the children are not being told what the colors mean and instead by playing a rhythm and observing what happens with the instruments, the children have to figure out what the colors mean. An improvement of the instruments mentioned by one of the participants would be if the data were recorded and could be replayed after the exercise in order for the teacher to see which of the children had difficulties. This teacher preferred to practice again with the less skilled students rather than supporting them during the exercise.

5.4.3.3 Feedback on the 'instruments with matching colors' video

Also, the sync videos were discussed. In these videos the instruments synchronize in groups of the same colors. The participants also had to tell what they thought the feedback meant. This feedback was the least clear according to the participants, however, all of them were able to tell which children played the same rhythm. What the white instrument meant was not clear without instruction; four of the participants thought that the students with a white instrument had stopped playing and one participant thought the white instrument represented a correct rhythm. The majority of the participants mentioned that this exercise was very difficult and two mentioned that it could best be used in upper grades of primary school since those children are often more advanced already. However, another participant mentioned that it would be best to apply these exercises in lower grades of primary school and make the upper grade exercises more advanced. Also, the majority of the participants mentioned that this kind of exercise needs proper class management using small and easy steps to prevent chaotic situations. Additionally, some of the participants mentioned that they would demonstrate the rhythm to be played or let one of the children demonstrate the rhythm before playing the rhythms simultaneously or all together. The opinions regarding the colors varied among the participants. Two participants mentioned that the colors were easily differentiable in both situations. One participant preferred the red, green and blue video while another participant preferred the one using aqua, yellow and purple. And another student said that both situations were not very clear. Also, the exercises offered were discussed. Generally, these ideas were positively rated, however, according to the participants most of the exercises require proper class management, for example by dividing the children into clear groups, demonstrating rhythms, applying small and easy steps or playing rhythm in turns. Lastly,

some of the participants offered additional exercise ideas using this type of feedback. One of the participants mentioned that she could use this for her class about continents in which she could play a rhythm for each continent. Another idea mentioned was rhythm memory, a game in which the children are grouped in duos and each duo has to think of an original rhythm and one of the children has to search for the duos by letting the children in turns play the rhythm they thought of with their buddy. If two children play the same rhythm, the searching child knows those two children are a duo. Also, some general ideas were offered like copying another child's rhythm or playing the same rhythm as another child without hearing his rhythm.

5.4.3.4 General/additional feedback

Lastly, some general feedback regarding colors, additional usage or ideas of the instruments was discussed with the participants. Regarding the differentiability of the colors four participants mentioned that the blue-greenish colors of the multicolor image looked much alike and three participants mentioned that the purple colors also looked alike. One student mentioned that most of the colors are clearly differentiable, but it would be hard to differentiate a lot of colors for a lot of children simultaneously. Some additional ideas offered by the participants on how to use these instruments were using flicking lights to indicate the tempo played by the children, using dimming lights or using the LEDs to show what the rhythm is that the children should play. Another idea offered was to turn the LEDs off in case a wrong rhythm is played. One of the participants mentioned, she thought that if a LED was turned off this would be less demotivating than a LED in a wrong color. Other ideas mentioned were using these instruments to teach children about dynamics, combining the instrument with singing or other instruments to form a small band. Or maybe to provide colored feedback based on body-sounds.

In the end, all participants mentioned that they were willing to use these instruments during their music class because they think it is stimulating, fun and a handy tool to provide feedback for the teacher. However, one of the students was still very cautious about using the instrument, would use the instrument only via small and easy steps and would maybe start practicing without the LEDs. This student also mentioned preferring to re-watch the data of the children after the music class. Another point mentioned by the participants was that it is difficult to guess how this instrument would be used in a real class, thus it would have been easier for them to give answers if the instruments could have been tested in a real class.

Generally, the lightening instruments are innovative and motivational and although some instruction is required in order for the participants to fully understand what is meant by the feedback, most of the feedback was intuitively interpreted correctly by the participants. Yet, some thinking should still be done regarding how to prevent demotivation due to failure or chaotic situations using the instruments.

5.5 User test discussion and proto-type improvements

For all of the ideas it holds that the feedback was mostly intuitive, however, instruction is needed on the details of the feedback and the possible usage of the instruments. A lot of the participants did understand what the feedback meant but had only a few ideas on how this feedback could be used in a class. Only after hearing the explanation or some example exercises the participants were able to come up with potential uses of the instruments. This means that to improve the usage of the instruments, a clear instruction explaining the feedback and how to potentially use the instruments should be developed for the teachers.

All of the pre-service teachers mentioned that they thought of the instruments as motivational, fun, innovative and a useful tool to use during their music class, however, some additional thinking is still required on how to prevent demotivation due to failure or chaotic situations. First of all, for all the ideas, a lesson-plan proposal can be made including ideas on how to manage a class properly and which small and easier steps can be applied in a class in case it is too difficult for some of the children. This could give the teachers a guideline on what to do when some children find it too difficult plus it might help teachers to manage the class. Ideas on this offered by the participants are ‘playing fewer rhythms simultaneously’, ‘divide the class into groups that have the same task’, ‘one person first demonstrates the rhythm to be played’, ‘first practice each of the rhythms individually before playing multiple rhythms simultaneously’, ‘stop the whole class in case a lot of students have difficulties and start over instead of correcting each of those children’, etc. Also, different gradations of difficulty can be explained for the teachers to be able to use these instruments in every grade of primary school. This lesson plan proposal could be included in the instruction. Another idea offered was to practice the exercises first without the lightening instruments. This would be an idea if the teacher already has a little knowledge of rhythms. In that case, the teacher can already teach the children about rhythms and use the instruments only to finalize the skills of the children. However, if the teacher also has no idea about the basics of rhythms, first practicing without the LEDs would have no additional use, since the children are not able to improve their skills before using the light feedback. Additionally, if the children are able to improve their skills, we think it would be very motivational for the children to see the change of the LED and notice that they have improved their rhythmic competences. And we think that the children who do not master the skills during that class do not profit from the practice before using the LEDs of the instruments, either. Yet, in all subjects, it always occurs that some children have more difficulties with the material than others, and we think, unfortunately, that this cannot be prevented. Therefore, we think that children could still be motivated to participate if the steps are not too difficult and if the exercises are alternated to make sure that a child does not have to focus on his or her incompetence for too long. Additionally, the instruments rating range could be adjusted to make sure that the instruments are less strict on when a rhythm is played wrong. Yet, this only helps to make an exercise easier for the entire class instead of for the less skilled children.

Another idea offered to help the less skilled children and to avoid chaotic situations is to split the class into smaller groups. This would be a good solution and we think that the lightening instruments would still be useful to guide a teacher during his or her music class. However, the goal of this project is to find an instrument that guides at least ten children and preferably even more. Thus, if it is necessary to divide the class into groups smaller than ten

children, this device should be changed or improved to obtain that goal. On the other hand, it was mentioned that even though it might be difficult for the teachers to look at all the children, the feedback can be very useful since the children might be able to improve their own skills due to the feedback, without needing additional help from the teacher. This way the instruments become self-learning devices for the children besides providing support for the teacher. Additionally, the instruments are supportive, since without this feedback it is also very hard to observe and support all children simultaneously, also in other subjects.

Of course, it is possible to look at how the feedback can be made friendlier towards the children. For example, in the brightness idea, the instruments could stay on instead of turning them completely off when a child makes a mistake, but the brightness would then only increase for the correct hits. However, in that case, the feedback is also less clear for the teacher. A compromise could be to still make the child who made the mistake start again; in that case, the teacher would still see the instrument flashing, but the brightness remains the same level. Additionally, a gamification element can be added to increase the children's motivation. In that case, for example, the instruments can turn green when the 'highest' level of brightness is achieved. This way the children have a goal to accomplish. Especially if the brightness level of the instruments stays the same each time a child makes a mistake, the goal of the instrument turning green can still be achieved and thus it is less demotivating if a child makes a mistake. In case of the tempo and sync exercises, another idea that was offered was to turn the lights off or to dim the lights if a child is playing the rhythm wrong. This participant argued that this would be less demotivating than a wrong color LED. However, we question whether this is true, we would say that it is even more demotivating to have no light instead of a wrong colored light. Another student mentioned that this way of feedback is motivational since the children might be motivated to keep their instrument the right color. This aspect can also be seen as gamification. Moreover, in the case of the sync exercises, it depends on the type of exercise whether a child can actually play a rhythm 'wrong', since this feedback only shows which children are playing the same rhythm. The feedback itself does not imply whether a child is making a mistake or not. Nevertheless, an experiment should be done using children and their reaction to the feedback of the lightening instruments to find out which scenario would be better.

Concerning the colors, there are a lot of different opinions among the participants. For some, the colors could easily be differentiated while for others it was very hard to see the differences. Of course, the observability of the colors is influenced due to the filming and maybe it also depends on the kind of screen the videos are being watched on. Also, the angle at which the instruments are being observed in the video is different compared to a real-life class. Additionally, based solely on the simulation it is very hard to interpret, how clear the feedback of the instruments is in a real class. Therefore, it would be best if the user test could have been executed in real life instead of online, preferably in an actual class using actual instruments. Thus, based on this user test, only very little conclusions can be made regarding the colors of the instruments to be used.

One of the participants mentioned that the instruments could be improved if the feedback of the instruments was recorded. The reason for this is that the teacher could replay the exercises to be able to provide additional support to the children in need of that. Also, she said that she preferred to provide support for the children after the exercises instead of during

the exercises. Yet, based on the literature generally real-time feedback and support is preferred and thus the focus of this project was to provide real-time feedback. However, for future projects, it would definitely be possible to make recording possible for the teacher. We also think that there are a lot of possibilities in how to give shape to this, for example providing additional text-based feedback or providing the teacher with example exercises to train the skills in which most of the mistakes were made by the children. Yet, I think that this would be a whole new or different way of providing feedback for the teacher and this would thus be an idea for future research.

Also, some exercise ideas were offered using these instruments. These ideas were very interesting and creative. For most of the ideas, the equipment does not have to be adjusted since these exercises could be practiced using the current prototype ideas. Therefore, these ideas could be included in the instruction to serve as inspiration, but are not necessary to include since teachers will come up with additional creative ideas if the instruments are being used for music classes. Also, some ideas were offered regarding other aspects of music like dynamics, other instruments or body sounds etc. but since this project is focused on rhythms using a 'sound shape' those ideas are out of scope for this project. These ideas are interesting, but could better be investigated in future research. The rhythm memory idea, offered by one of the participants is something new that could still be built. The instruments should then not be programmed to turn the same color as another instrument playing the same rhythm, but instead the instruments should turn a color matching a specific rhythm. This idea could be a variation of the idea explained in 3.1.2 and could still be programmed to broaden the possibilities using this equipment.

In short, the prototype could be improved by including:

- Instruction on what the feedback means and how the instruments can be used.
- Lesson-plan proposals including easy steps and how to manage a class.
- A difficulty gradation including advice per grade.
- More friendly feedback in case a child makes a mistake.
- Gamification elements.
- Code ideation idea of 'Colors matching a specific rhythm' explained in 3.1.2

5.6 Conclusion on realization

During the realization, the first hardware used was the Wemos d1 mini via which a WIFI connection was built to connect three Wemos devices to be able to control all of the necessary LEDs. However, using this system, the connection had a huge delay which resulted in a too slow working device and therefore, the Wemos d1 mini WIFI connection was not successful. Thereafter, the multiplexer 74HC4067 was used. This chip was able to control all of the LEDs without delay, yet, the multiplexer was not able to control some LEDs simultaneously without influencing other LEDs due to the binary control. Thus, another device was used, namely, the TLC5940 LED driver. This LED drive was successful in controlling all of the LEDs like they were supposed to work.

The prototype design consisted of a paper box with ten simulated children each holding their own lightening instrument. The hardware was located inside the box with the LEDs connected to a paper funnel underneath each of the instruments. Inside the funnels, aluminum was attached to spread the light rays over the complete area of the drums.

User tests were done using videos of the prototype to find out what pre-service teachers think of the idea regarding how the instruments can be improved, how the instruments can be used in class, and to what extent they think the instruments are supportive for their music class. In total five third-year (all happened to be female) PABO students were willing to participate in the user test. All of them found the prototype very interesting and thought the instruments were motivating, fun, supportive and innovative, however, some instruction is still required to optimally incorporate the instruments into a music class and a large point of attention is how to avoid demotivation due to failure and chaotic situations in class. Additionally, some nice ideas were offered on how the instruments could be used otherwise. To improve the prototype based on the feedback given by the participants, some additional elements could be included like gamification elements and a clear instruction including how to use the instruments, lesson-plan proposals and difficulty gradations per exercises. Also, some of the feedback could be made friendlier towards the children and some additional coding ideas could be implemented.

Chapter 6 – Conclusion and discussion

During this project, a prototype was built simulating a class using lightening instruments. In the literature, we found that feedback is supportive for a teacher if the feedback indicates which of the children makes a mistake at which moment and can easily be understood. Additionally, it would be helpful if the instruments also contribute to the learning process of the children. Research about visual feedback in general concluded that visual feedback has opportunities to optimize the learning process by combining multiple stimuli, incorporating embodied learning, giving real-time feedback and being motivational.
From the user tests it emerged that the feedback is clear, but some instruction is needed. Preferably this instruction would include how the instruments can be used, as well as lesson-plan proposals and a difficulty gradation. Furthermore, thoughts should be given to the question of how to limit chaotic situations during class or demotivation among children due to failure. Besides, based on the user test it can be said that the lightening instruments are innovative, fun, motivational and helpful for the teachers. To conclude, when instruments providing color-based feedback are used to guide beginning teachers in teaching rhythmic synchronization and entrainment, various aspects could be taken into account. First of all, colors are a good medium to provide the teacher with feedback on the rhythmic performances of each of the children. Additionally, this type of feedback is found motivating, fun and innovative which engages the children in the music class resulting in more attention of the children and thus an enhancement in their learning process. However, still some instruction is required that informs the teacher about how to use the instruments and how the feedback should be read. Additionally, this instruction should include example exercises using these instruments and lesson-plan proposals to serve as inspiration on how to manage a class. Also,

a difficulty gradation should be included in the instruction to allow the teacher to use the instruments in different grades of primary school and to switch exercises in case an exercise is perceived as too easy or too difficult. And lastly, some improvements could be made in the feedback to make the feedback a bit more child friendly in order to prevent frustration or demotivation among the children due to failure. Overall, instruments providing color-based feedback can guide beginning teachers in teaching rhythmic synchronization and entrainment by visualizing the rhythm performances of each of the children using colored instruments if instruction is given to the teachers and the children maintain their motivation and involvement.

Due to circumstances of the coronavirus, this project faced some restrictions. Therefor, some experiments that were now restricted could be investigated in future research. For example, the user test execution was somewhat more limited. Therefor, it was not possible to do the test physically, or in a real claass setting and thus we had to resort to using videos of a simulation for the user test, which carried some minor obstacles. First of all, filming colored lights is difficult with as a result that the colors of the instruments in the video were sometimes hard to distinguish. Additionally, the sound fragment did not sound realistic which could have caused some confusion among the participants. Also, the participants could only try to imagine how the instruments would work in a real class. For these reasons, we recommend to test these instruments in a real class setting in a future research. Moreover, the user test only asked pre-service teachers and they pictured how the children would respond to the lightening instruments. Yet again, these could be wrong interpretations and thus for further research it would be advised to include the child’s opinion in the user test.

Besides examining how teachers and children would react on lightening instruments in a real class setting, also some other future researches could be done regarding this topic. For example, research could be done investigating other possible exercises or other usage of these enlightened instruments. Another research could be about the effect of combining different exercises into one instrument. Would the teacher be able to separate the individual ideas or would the teacher mix up the definition of the colors? Or: How can the colors be used to prevent confusion? Another research could be about other aspects of music, for example, dynamics or pitch. Could color-based feedback also support this kind of music classes and how? And of course, research could be done on recording the feedback from the instruments and on how to visualize the recordings.

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Appendices

Appendix 1 – A literature review on supporting generalist teachers, in teaching rhythm in primary education – by Jenneke van Beurden

A literature review on supporting generalist teachers, in teaching rhythm in primary education

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Search terms: primary education, Music education, visual feedback, Generalist teacher, Rhythm, real-time feedback, support, primary school

Introduction

Music in primary education is an important subject in order to enhance children's development because it contributes to both the left and the right side of the brain. Additionally, music builds confidence and creativity, brings variety in the learning methods and it promotes learning about culture (Joseph, 2015). In primary education, the music classes are mostly given by generalist teachers. However, due to the lack of time in their own education, generalist teachers are not being educated properly on how to teach music. Consequently, the teachers lack competences and confidence on their musical (teaching) knowledge. As a result, the generalist teachers skip or reduce the music classes when educating at a primary school, or the quality of the class is poor if music classes are given. (Wiggins, & Wiggins, 2008; Joseph, 2015). Therefore, it is important that pre-service teachers receive support on how to teach music to increase their competences and confidence.

In order to provide effective support, technology can be used to guide the teachers by providing them and the children visual feedback on the students' live performance. Technology is a possible solution since it offers multiple modalities that allow for interactive, interesting learning activities and real-time visual feedback (Kersten, 2006). However, in order for the feedback to be effective for the teacher, yet not be distracting towards the children, it should be known when a class is successful for the children and what kind of feedback a teacher needs in these classes to properly educate the children. These aspects can be found in literature and form a base for the to be developed technological feedback device. Music is a broad subject and the client of the project is interested in classes about rhythm. Therefore, the rhythmic aspect of music is the focus of this paper. Thus, this research paper gives insights on the above-named aspects related to rhythm in order to find an answer to the question *How can visual feedback be used to provide effective support for (pre-service)*

generalist teachers in teaching rhythmic synchronization and entrainment in primary education.

This paper consists of four parts, the first part will provide information on how to make a class efficient and useful to educate rhythms. Secondly, will be explained what the conditions are to make the feedback for a teacher supportive. Thereafter, the challenges and opportunities of visual feedback will be discussed. And lastly, some previous projects on visual feedback will be analysed. At the end of the report, our findings will be concluded.

Effective classes

In order to make the music class effective, two important factors should be incorporated. First of all, children need motivation during class (Nijs, & Leman, 2014; Xiao, Puentes, Ackermann, & Ishii, 2016). According to Nijs and Leman (2014), more motivation leads to more attention, and thus children absorb more information resulting in optimised learning. Additionally, Xiao et al. (2014) say that children often face difficulties in focussing on a certain topic for extended time-periods if they find the topic uninteresting. Therefore, it seems that a class should motivate the students. The second factor is that children learn through sensory-motor symbolic understandings rather than abstract understandings. This means that a class including embodied learning or relatable figures for conveying musical structures and expressions resembles to be effective. Additionally, (Xiao et al., 2016). Lyu, Tian, Feng, Cao, Zhang, Dai and Wang (2017) suggest that embodied learning can reinforce music perception and creativity. Both motivation and embodied learning can be incorporated in a class by for example using games, social playing or overcoming challenges (Xiao et al., 2016). To summarise, using an interactive class setting that motivates the students via embodied learning is what makes a music class efficient and useful to educate about rhythms.

Supportive feedback

Besides knowing how to make a class effective, a teacher should know what to focus on in a class. Wiggins and Wiggins (2008) suggests that teachers need help in understanding the music, they often lack sophisticated listening skills and do not know what the musical problems are in a group of children. This implies that a generalist teacher is not capable of noticing when a rhythm is played incorrectly. Also, a generalist teacher needs help in observing each child as an individual while being in a class group (Wiggins, & Wiggins, 2008). Therefore, supportive feedback should be provided to the generalist teachers on how, where/who or when a rhythm is played wrong.

Furthermore, the feedback should not distract either a teacher or the children. Hereof, Hoppe, Brandmeyer, Timmers, & Desain, 2008; Nijs, & Leman, 2014 suggest that feedback should not add too much (extraneous) cognitive load (CL). Kirschner (2002) says that CL is a term related to the limitations of the working memory (WM) capacity. The load of the WM is influenced by the intrinsic CL, the extraneous CL and the germane CL. The intrinsic CL is related to the difficulty of the instruction and remains unchanged in education. The extraneous CL concerns how the information is portrayed and could be distracting. And the germane CL is the load that is required to actually process the information. The total CL is the total of these three loads. The required WM should not be too high to be able to process the information, and thus should instruction require germane CL rather than extraneous CL (Kirschner, 2002). Aside from already having difficulties with teaching rhythm, a generalist teacher also has many aspects to focus on in a music class like sound, the enthusiasm of the children and educating them. Therefore, the feedback should rather reduce than increase the cognitive load of the teacher.

To prevent the feedback from increasing the CL, visual feedback that feels natural or intuitive should be used. Hoppe et al. (2008) proposed this to be more effective than

modelling the interactions since that would add another aspect that the teacher should take into account and analyse while teaching. Lastly, Hoppe et al. (2008) also say that real-time feedback is most effective because this allows the teacher to immediately react to the performance of the students. Thus, it shows that in order for the feedback to be supportive for the teacher it should be real-time, intuitive and it should give insight on the (individuals) execution of the rhythm, without increasing cognitive load.

Opportunities and challenges of Visual Feedback

One way of providing this feedback is by using visual feedback since visual feedback acquires multiple opportunities to create an interactive class. According to Nijs, Coussement, Muller, Lesaffre and Leman (2010) and Xiao et al. (2016) for example, it can be used to create a connection between auditory, visual and tactile stimuli, which is crucial in developing perceptions of music. This is because presenting learning materials via multiple modalities allows the learners to more effectively process the content via neural connections (Nijs, & Leman, 2014; Xiao et al., 2016). It especially enhances the process of musical creation if the visual feedback is congruent to the auditory incentives (Nijs et al., 2010). Additionally, visual feedback can incorporate sensory-motor learning for the children by including visual enactments or figures to educate about rhythms as is said by Xiao et al. (2016). Also, Nijs and Leman (2014) say that due to the many possibilities, visual feedback can reinforce multiple didactic practices like free (explore and see what happens) and guided (try to complete the task) exploration. In short, visual feedback offers many possibilities to enhance the interactivity in a class by combining multiple stimuli and incorporating sensory-motor learning.

Besides the opportunities to create an interactive class, there are more advantages and challenges of visual feedback that can be taken into account. An advantage of visual feedback

implied by Nijs and Leman (2014) is that the feedback can be given real-time instead of after the performance. Also, the feedback is objective since it is based on data, thus the music can not be wrongly interpreted by the teacher. Thereby, Hoppe et al. (2008) suggest that the feedback should be unambiguous, else the feedback might not be clear which increases the CL of either the teacher or the children. Additionally, Nijs and Leman (2014) and Xiao et al. (2016) name that learner's motivation and attention can be stimulated by colors, immediate feedback, (social) challenges to obtain goals or gamification as another advantage of visual feedback. However, Xiao et al. (2016) mention that providing feedback as a score might discourage a student's motivation due to stress, the idea of failing, or a displeasing score. Furthermore, Nijs and Leman (2014) say that a challenge of technology is that the system can not breakdown since this as well loses the attention on the task. To sum up, if the visual feedback is not discouraging and does not increase the CL, there are many possibilities for using visual feedback as effective support for teachers in teaching rhythms.

Practical experiences of Visual Feedback

In previous projects, researchers already gained experiences on how visual feedback can be used in music classes and its effectiveness. An example of a project using visuals as feedback is the Sync-in-Team which is a game aiming at learning about music via social interaction explained in Leman, Demey, Lesaffre, Noorden and Moelants (2009). The Sync-in-Team uses colour projections on the floor. Each of the colours represents a specific team and a larger the projection represents a better team-score. The research concluded that almost all of the test participants liked the visualization. Yet, the visualization was not sufficiently clear. One-third of the people had difficulties with understanding the feedback, which increased their cognitive load. Also, the feedback was not focussed on individual differences, which is

what we want for the teacher feedback. To conclude, the feedback of the Sync-in-Team resembles to require some improvement to be effective support for teachers.

A different project using visual feedback is the music paint machine. The Music paint machine reported in Nijs et al. (2010) is an interactive machine focussing on being creative with music but also allows to do exercises using cards. The feedback is displayed on a screen, and through making music, different colours appear at different places on the screen dependant on what kind of music is played and how. This feedback was very effective since it allowed for individual reflective discussion via artistic creations as documentation, and it can include gamification or challenges to achieve. Thus, if the music paint machine shows success in creating an interactive and motivational class using visual feedback.

Another project is the BeatLED, which is a social music game in which the feedback is given using lights that are supposed to display a score. Nies, Vervust, Demey, Leman, Vanfleteren and van de Walle (2012) researched the effects of using the BeatLED. the idea of the feedback is: ‘the more lights, the higher the score’. However, the feedback display turned out to be difficult to understand for most of the people, which increased the cognitive load for the people. Also, this feedback does not inform users on their performance, but it only states if a person is doing good or bad, which can be demotivating. In short, it seems that the feedback of the BeatLED should be improved in order to be effective.

Conclusion

The discussed projects are great examples that show the practical aspects of the literature. It is proven that visuals can be very effective as a means of feedback, but only if it is motivational and does not enlarge the cognitive load. Thus, based on the literature an answer can be given to the question ‘*How can visual feedback be used to provide effective support for (pre-service) generalist teachers in teaching rhythmic synchronization and entrainment in*

primary education.' Visual feedback can be used to provide effective support for teachers to teach rhythms by making sure that the feedback allows for an interactive and motivational class, by ascertaining clear insights to the teacher on how to guide the students real-time, and by minimizing the chances of cognitive load increases for either the teacher or the students.

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Appendix 2 – Table of colors with meanings, connotations and emotions:

Zammitto. L.V. (2005). Colours and meanings, connotations, emotions [table]. DiGRA conference, 3, 4. Retrieved from: http://www.sfu.ca/~vzammitt/papers/zammitto-digra-TheExpressionsofColours.pdf

Colour	Meanings, connotations, emotions
Black	Death, unbearable, evil, criminality, hidden aspects, sinister, depression, grief, pain, repression, hopelessness but also sophistication, authority, style. [6, 22] Regarding clothes, black is the colour of mourning in almost all occidental countries, also used as penitence for monks/nuns. [4]
Blue	Cold, peace, depression, sadness, relax, calm, piety, wisdom, introspection, solitude, loneliness, contemplation, distance, infinitude, emotion control; it represents water and the sky. [1, 4,16, 22, 24] Spoils appetite.
Brown	Wood, comfort, ground, earth, substance, physical, worn [4, 24]
Gold	Value, honour, loyalty. [16, 22]
Green	Nature, fertility, fecundity, balance, youth, also water. It induces to tranquility. [4, 22] In western culture, money. During medieval age, brides married wearing green as a manifestation of her fecundity. See figure 4.
Grey	Neutrality, fusion of happiness and sadness. [22]
Orange	Vital force, strength, endurance, social behaviour, warm. [4]
Red	Love, passion, excitement, appetite, health, courage, majesty, hot, danger, blood, weapons, aggressiveness, power, fire, hell. [1, 16, 22] It is the colour bride should wear in China, it means happiness there. See figure 4. [4] Red increases blood pressure, muscle tension and grip strength [5]; unfortunately, mouse and console's pads have no feature that measure pressing.
Violet	Mysticism, royalty, high range. [4]. It is a mourning colour in China. [1]
White	Light, purity, innocence, cleanness, cold. Western bride wears white to represent her chastity. See figure 4. In China it represents Autumn.
Yellow	Seems to stimulate the nervous system, it is linked to intelligence, logical thinking, innovation, spirituality, hope, joy, delicate. [1, 4] It is used to represent the sun that through history is the one that allow life. [23] But, when it is a dingy yellow it would be more likely to cowardice, ruin, shame, illness, decadence. For its brightest version, rage.

Appendix 3 – Leerlijn Muziek SLO (learning guideline for music by the Curriculum Development Foundation (SLO))

Stichting Leerplan Ontwikkeling. (2019). Leerlijn Muziek [table]. Retrieved from https://slo.nl/thema/vakspecifieke-thema/kunst-cultuur/leerplankader-kunstzinnige-orientatie/leerlijnen/

LEERLIJN MUZIEK

	Competenties groep 1-2	Competenties groep 3-4 *als groep 1-2 plus:*	Competenties groep 5-6 *als groep 1-4 plus:*	Competenties groep 7-8 *als groep 1-6 plus:*	Streefcompetenties muziek
REFLECTEREN – ORIËNTEREN	De leerling kan actief luisteren naar korte stukken (live) muziek(-theater) uit een breed repertoire, aansluitend bij zijn belevings-wereld. De leerling kan met taal, beweging of beeld zijn eigen betekenis geven aan muziek in binnen- en buitenschoolse situaties.	De leerling kan actief luisteren naar (live) muziek uit een breed muziek(-theater) repertoire, aansluitend bij zijn belevings-wereld. De leerling kan kennisnemen van betekenissen die anderen aan muziek geven, waaronder de componist.	De leerling kan objectief kennisnemen van betekenissen die anderen aan muziek geven, waaronder de componist.	De leerling kan (binnen een inspirerende werkvorm) met aandacht luisteren naar muziek van buiten zijn belevingswereld. De leerling kan de eigen betekenisgeving aan muziek spiegelen aan die van anderen, en staat daarbij open voor andere ideeën.	• De leerling kan betekenis geven aan (live) muziek uit verschillende tijden, stijlen en culturen[1], kan kennis nemen van betekenissen die anderen daar aan geven (waaronder de componist of uitvoerder) en kan deze aan die van hemzelf spiegelen.
REFLECTEREN – ONDERZOEKEN	De leerling kan betekenissen en klanktegenstellingen in muziek van een breed repertoire onderscheiden en vertalen naar beweging en beeld. De leerling ontdekt, door manipuleren en experimenteren, klankaspecten van diverse klankbronnen. De leerling kan zelfstandig een situatie, sfeer of muzikale tegenstelling verwerken in kleine vocaal/instrumentaal geïmproviseerde klankstukjes. De leerling kan zijn muzikale ideeën globaal weergeven in beeld (picturaal, basaal grafisch).	De leerling kan verschillen in klank en de vormaspecten herhaling en contrast in een breed repertoire van muziek herkennen en benoemen. De leerling kan muziekstukjes ontwerpen met (willekeurige) gebruikmaking van muzikale tegenstellingen, herhaling en contrast. De leerling kan zijn muzikale ideeën picturaal en grafisch weergeven en reproduceren.	De leerling kan muzikale thema's in muziek van een breed repertoire herkennen en benoemen. De leerling kan met gebruikmaking van klank- en vormaspecten van muziek bewust structuur aanbrengen in zijn composities.	De leerling kan variaties op thema's in muziek herkennen en analyseren. De leerling kan variatie als vormprincipe toepassen in zijn composities. De leerling kan zijn muzikale ideeën vormgeven en eventueel verklanken met gebruikmaking van (muziek)technologie. De leerling kan specifieke klankaspecten onderscheiden en die weergeven in passende grafische symbolen.	• De leerling kan gericht luisteren naar muziek uit verschillende tijden, stijlen en culturen, en kan daarin de klank-, vorm- en betekenisaspecten herkennen en benoemen. • De leerling kan klank-, vorm- en/of betekenisaspecten van muziek in zijn composities verwerken en daarbij de vormprincipes herhaling, contrast en variatie toepassen. • De leerling kan zijn muzikale ideeën vormgeven en uitvoeren met behulp van zijn stem, (school)instrumentarium, (muziek)technologie en beweging. • De leerling kan zijn composities noteren en reproduceren met behulp van picturale en grafische notatievormen.
UITVOEREN	De leerling kan in groepsverband eenstemmige liedjes, zowel 2- als 3-delig, binnen een omvang van c'-b', met de leerkracht meezingen. De leerling kent een breed repertoire liedjes en versjes, passend bij zijn directe belevingswereld. De leerling kan volgens de vorm van het lied fraseren. De leerling kan maat en tempo van muziek in beweging weergeven.	De leerling kan zuiver, helder gearticuleerd en met expressie zingen in een omvang van c'-c''. De leerling kan meezingen met een begeleiding. De leerling kent liedjes in meerdere talen en van diverse culturen.	De leerling kan een lied zelfstandig correct zingen. De leerling kan in canon zingen.	De leerling kent meerdere canons.	• De leerling kan (zelfstandig, zuiver, helder gearticuleerd en met expressie) liederen en canons zingen, al dan niet met begeleiding. • De leerling kan zelfstandig, ritmisch en in de maat, eenvoudige ritmische en melodische (begeleidings)patronen en speelstukken uitvoeren, zowel een- als meerstemmig, en kan daarbij reageren op (lied)leidingsgebaren. • De leerling kan alleen en in groepsverband bestaande, eenvoudig grafisch en traditioneel genoteerde composities zowel auditief volgen als uitvoeren. • De leerling kent de namen en

[1] Muziek uit verschillende tijden, stijlen en culturen is van toepassing op alle hierna te noemen: 'te beluisteren muziek'

Bron: www.kunstzinnigeorientatie.slo.nl

Leerplankader kunstzinnige oriëntatie primair onderwijs

REFLECTEREN – EVALUEREN	De leerling kan (in groepsverband) eenvoudige ritmische patronen uitvoeren. De leerling kan bij het musiceren in groepsverband gelijk beginnen en eindigen aan de hand van een (lied)leidingsgebaar. De leerling (her)kent de relatie symbool/klank en kan onder leiding van de leerkracht picturale en grafische notaties verklanken. De leerling kent de namen en speelwijzen van het in de onderbouw (van het primair onderwijs) meest gebruikte schoolinstrumentarium. De leerling kan zich tijdens het musiceren qua tempo en volume aanpassen aan dat van de groep. De leerling kan (alleen en in groepsverband) een kort muziekstukje onder leiding van de leerkracht aan anderen presenteren. De leerling kan over zijn muzikale ideeën vertellen, met gebruikmaking van basale muzikale begrippen. De leerling kan met aandacht luisteren naar de ideeën van anderen. De leerling herkent de betekenis van muziek in voor hem relevante jaarfeesten, situaties en emoties.	De leerling kan de maat en eenvoudige ritmische (begeleidings-) patronen uitvoeren. De leerling kan adequaat reageren op eenvoudige (lied)leidingsgebaren voor maat/puls. De leerling kan in groepsverband picturaal en eenvoudig grafisch genoteerde composities uitvoeren. De leerling kent de namen en speelwijzen van het schoolinstrumentarium en van enkele veelvoorkomende instrumenten van het pop- en (Westerse) klassieke instrumentarium. De leerling heeft bij het musiceren in groepsverband aandacht voor het samen zingen en spelen. De leerling kan (alleen en in groepsverband) een kort muziekstukje aan anderen presenteren. De leerling kan (in overleg) muzikale keuzes maken en daarover vertellen. De leerling kan feedback geven op het werk(proces) van anderen. De leerling heeft enige kennis van de plaats van muziek in het leven van mensen van vroeger en nu.	De leerling kan eenvoudige ritmische en melodische (begeleidings)patronen uitvoeren. De leerling kan adequaat reageren op een inzetgebaar bij canonzingen. De leerling kan bestaande grafisch- en traditioneel genoteerde composities auditief volgen en uitvoeren . De leerling kan tijdens het musiceren luisteren naar anderen en een kwalitatieve bijdrage leveren aan het gezamenlijke muzikale resultaat. De leerling kan (alleen en in groepsverband) een eigen idee of bestaande compositie aan anderen presenteren. De leerling kan de gemaakte keuzes uit zijn muzikale ideeën en alternatieven toelichten. De leerling kan constructieve feedback geven en van anderen ontvangen. De leerling heeft enig inzicht in de invloed van muziek op mensen door middel van massamedia.	De leerling kan eenvoudige ritmische en melodische (begeleidings)patronen spelen binnen meerstemmigheid. De leerling kent de namen en speelwijzen van het schoolinstrumentarium en die van het pop- en (Westerse) klassieke instrumentarium. De leerling kan presenteren met overtuiging. De leerling kan ontvangen suggesties verwerken in zijn werk(proces). De leerling heeft enig inzicht in de manier waarop muziek het gedrag van mensen kan beïnvloeden.	speelwijzen van het schoolinstrumen-tarium en die van het pop- en (Westerse) klassieke instrumentarium. • De leerling kan (alleen en in groepsverband) een eigen idee of bestaande compositie uitvoeren en presenteren aan anderen en doet dat met overtuiging. • De leerling kan overwogen keuzes maken voor zijn composities en die communiceren met anderen. • De leerling kan constructieve feedback geven. • De leerling staat open voor feedback en kan die eventueel verwerken in het eigen werk(proces). • De leerling heeft enige kennis van en inzicht in de betekenis die muziek heeft voor het dagelijks leven van mensen van vroeger en nu, zoals feesten, verdriet, massamedia en beïnvloeding van gedrag.

Bron: www.kunstzinnigeorientatie.slo.nl

Leerplankader kunstzinnige oriëntatie primair onderwijs

Appendix 4 – Codes using Wemos d1 mini WIFI connection

4a – Arduino code of the server Wemos d1 mini in the connection between two Wemos devices

```
/*Jenneke van Beurden - s1988891

  This is the server code of the WIFI connection between 2
Wemos d1 minis

  This code created a loop between the 2 wemos devices:
  1) the client asks the host to turn his leds on
  2) the server turns his leds on and sends the client a
     response that the leds are on
  3) the client reads that the leds of the server are on and
     turns his own leds off as well
  4) the clients leds are off and ask the server to also turn
     his leds off
  5) the servers leds are off and sends the client a response
     that the leds are off
  6) the client reads that the leds of the server are off en
     turns his own leds on
  7) the clients leds are on and the loop starts over at step
     1: the client asks host to turn his leds on

  If the Leds are one, they will light up after each other
 with increasing brightness
 */
#include <ESP8266WiFi.h>    //wifi library
#include <WiFiClient.h>
#include <ESP8266WebServer.h>
#include <ESP8266mDNS.h>

ESP8266WebServer server(80);

// Network SSID
const char* ssid = "home network ssd";
const char* password = "password of home network";

int r, i;
int redPins[] = {15, 14, 0};      //array for red pins
int greenPins[] = {13, 16, 4};    //array for green pins
int bluePins [] = {12, 2, 5};     //array for blue pins
#define FADESPEED 1000            // make this higher to slow
down
#define INCREASE 250              // make this higher to
decrease the brightness loop
```

```
void setup() {

  Serial.begin(115200);           // open serial monitar
  delay(10);


  //pinmodes for all the pins are set to 'output'
  for (int i = 0; i < 3; i++) {
    pinMode(redPins[i], OUTPUT);
    pinMode(greenPins[i], OUTPUT);
    pinMode(bluePins[i], OUTPUT);
  }


  // Connect WiFi
  Serial.println();
  Serial.println();
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);


  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

  // Print the IP address
  IPAddress myIP = WiFi.localIP();
  Serial.print("IP address: ");
  Serial.println(myIP);

  server.on("/On", saturation); // start saturation if ip
                                address is  browsed
  server.on("/Off", led_off); // turn led's off

  server.begin();
  Serial.println("HTTP server started");


}

//turns the servers lights off
void led_off() {
  Serial.println("Led_off");
  for (i = 0; i < 3; i++) {
    analogWrite(redPins[i], LOW);          //turn red off
    analogWrite(greenPins[i], LOW);        //turn green off
```

```
    analogWrite(bluePins[i], LOW);        //turn green off
  }

  //responds to the client that the leds are off
  server.send(200, "text/plain", "sent Led_off");
}

//turns leds on with increasing saturation
void saturation() {
  //loop that increases saturation
  Serial.println("Saturation");


  //responds to the client that the leds are on
  server.send(200, "text/plain", "sent Led_on");
  for (r = 0; r < 1001; r = r + INCREASE) {
    analogWrite(redPins[i], r);          //increase red
saturation
    analogWrite(greenPins[i], r);        //increase green
saturation
    analogWrite(bluePins[i], r);         //increase blue
saturation
    delay(FADESPEED);
    i++;          //next pin
    if (i > 2) {
      i = 0;     //one wemos has only 3 led's
    }
  }
}


void loop() {
  server.handleClient();
}
```

4b – Arduino code of the client Wemos d1 mini in the connection between two Wemos devices

```
/*Jenneke van Beurden - s1988891

  This is the client code of the WIFI connection between 2
 Wemos d1 minis.

  This code created a loop between the 2 wemos devices:
  1) the client asks the host to turn his leds on
  2) the server turns his leds on and sends the client a
     response that the leds are on
```

```
  3) the client reads that the leds of the server are on and
    turns his own leds off as well
  4) the clients leds are off and ask the server to also turn
    his leds off
  5) the servers leds are off and sends the client a response
    that the leds are off
  6) the client reads that the leds of the server are off and
    turns his own leds on
  7) the clients leds are on and the loop starts over at
    step 1: the client asks host to turn his leds on

  If the Leds are on, they will light up after each other
 with increasing saturation
 */
#include <ESP8266WiFi.h>    //wifi library
#include <WiFiClient.h>
const char* host = "192.168.***.**";    //IP address of host

// Network SSID
const char* ssid = "home network ssd";
const char* password = "password of home network";

int r, i;
int redPins[] = {15, 14, 0};      //array for red pins
int greenPins[] = {13, 16, 4};    //array for green pins
int bluePins [] = {12, 2, 5};     //array for blue pins
#define FADESPEED 1000            // make this higher to slow
down
#define INCREASE 250              // make this higher to
decrease the saturation loop
bool command = true;              // boolean for next command

void setup() {
  Serial.begin(115200);           // open serial monitor
  delay(10);

  //pinmodes for all the pins are set to 'output'
  for (int i = 0; i < 3; i++) {
    pinMode(redPins[i], OUTPUT);
    pinMode(greenPins[i], OUTPUT);
    pinMode(bluePins[i], OUTPUT);
  }


  //connect to wifi
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
```

```
  }
  Serial.println("");
  Serial.println("WiFi connected");

  // Print the IP address
  Serial.print("IP address: ");
  Serial.println(WiFi.localIP());

}

void loop() {

  //connection with host
  Serial.print("connecting to ");
  Serial.println(host);

  // Use WiFiClient class to create TCP connections
  WiFiClient client;
  const int httpPort = 80;
  //check connection
  if (!client.connect(host, httpPort)) {
    Serial.println("connection failed");
    return;
  }

  //create a URI for the request
  String url_on = "/On";
  String url_off = "/Off";

//ask the server to turn the leds on if 'command' is true
  if (command && client.connect(host, httpPort)) {
    client.print(String("GET ") + url_on + " HTTP/1.1\r\n" +
                 "Host: " + host + "\r\n" +
                 "Connection: keep-alive\r\n\r\n");
    delay(10);
    Serial.println("command");
//ask the server to turn the leds off if 'command' is false
  } else if (!command && client.connect(host, httpPort)) {
    client.print(String("GET ") + url_off + " HTTP/1.1\r\n" +
                 "Host: " + host + "\r\n" +
                 "Connection: keep-alive\r\n\r\n");
    delay(10);
    Serial.println("No command");
  }

  // Read all the lines of the reply from server and print
    them to Serial Monitor etc
  while (client.available()) {
    String line = client.readStringUntil('\r');
    Serial.println("Response: " + line);
```

```
  //if the server sent Led_off (servers lights are off), do
   saturation (lights of client on)
    if (line.indexOf("sent Led_off") > 0) {
      Serial.println("1");
      saturation();
  //if the server sent Led_on (de servers lights are on), do
   led_off (lights of client off)
    } else if (line.indexOf("sent Led_on") > 0 ) {
      Serial.println("2");
      led_off();
    }
  }
}

//turns the clients lights off
void led_off() {
  Serial.println("Led_off");
  for (i = 0; i < 3; i++) {
    analogWrite(redPins[i], LOW);          //turn red off
    analogWrite(greenPins[i], LOW);        //turn green off
    analogWrite(bluePins[i], LOW);         //turn green off
  }
  delay(2000);
  command = false;    //command boolean is false --> ask
                    server to turn lights off
}

//turns leds on with increasing saturation
void saturation() {
  //loop that increases saturation
  Serial.println("Saturation");
  for (r = 0; r < 1001; r = r + INCREASE) {
    analogWrite(redPins[i], r);          //increase red
saturation
    analogWrite(greenPins[i], r);        //increase green
saturation
    analogWrite(bluePins[i], r);         //increase blue
saturation
    delay(FADESPEED);
    i++;         //next pin
    if (i > 2) {
      i = 0;    //one wemos has only 3 led's
    }
  }
  command = true;     //command boolean is true --> ask
server to turn lights on
}
```

4c – Arduino code of the server Wemos d1 mini in the connection between three Wemos devices

```
/* Jenneke van Beurden - s198889s

    This code is the Server code of the loop within the WIFI connection of
     3 Wemos d1 minis.

    In this code, the loop consists of several steps to turn on the LEDs
     of the Wemos devices:
1) client2 asks the server to turn on LEDs
2) server turns on LEDs and sends to client1 that lights can be turned on
3) client1 turns on LEDs and asks the server to tell client2 to turn on
    the LEDs
4) the server reads this request and sends to client 2 that lights can be
   turned on
5) client2 turns on LEDs and the loop starts at 1 again --> client 2 asks
   the server to turn on LEDs

In order for both clients to receive the correct response sent by the
server, both clients constantly sent request to the server
this request is either to say that they are connected or to ask the
server to turn on the lights of the next Wemos.
The server is regulating which Wemos has to turn on his light Using
booleans saying when to went which response to the Wemos devices.
If the LEDs are on, they will light up in turns with increasing
saturation and
thereafter they will automatically be turned off by the Wemos controlling
these LEDs.

*/

#include <ESP8266WiFi.h>    //wifi library
#include <WiFiClient.h>
#include <ESP8266WebServer.h>
#include <ESP8266mDNS.h>

ESP8266WebServer server(80);

//WiFiServer server(80);

// Network SSID
const char* ssid = "ssid of home network";
const char* password = "password of home network";

int r, i;
int redPins[] = {15, 14, 0};      //array for red pins
int greenPins[] = {13, 16, 4};    //array for green pins
int bluePins [] = {12, 2, 5};     //array for blue pins
#define FADESPEED 1000            // make this higher to slow down
#define INCREASE 250              // make this higher to decrease the
saturation loop
bool connectionClient1 = false;  // boolean to check the connection of
client 1
bool connectionClient2 = false;  // boolean to check the connection of
client 2
bool ledOn1 = false;              // boolean on whether the LEDs of client
1 should be on
```

```
bool ledOn2 = false;              // boolean on whether the LEDs of client
1 should be on



void setup() {

  Serial.begin(115200);     //start serial monitor
  delay(10);


  //pinmodes for all the pins are set to 'output'
  for (int i = 0; i < 3; i++) {
    pinMode(redPins[i], OUTPUT);
    pinMode(greenPins[i], OUTPUT);
    pinMode(bluePins[i], OUTPUT);
  }


  // Connect WiFi
  Serial.println();
  Serial.println();
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, password);


  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

  // Print the IP address
  IPAddress myIP = WiFi.localIP();
  Serial.print("IP address: ");
  Serial.println(myIP);


  server.on("/OnServer", saturation); // start saturation if ip adress is
                                          browsed
  server.on("/OnClient2", onrequestClient_2); // turn led of client 2 on
                                                ip address is browsed
  server.on("/connectionClient2", connectionClient_2); // connection
                                                         succeeded if ip
                                                         address is
                                                         browsed
 server.on("/connectionClient1", connectionClient_1); // connection
                                                         succeeded if ip
                                                         address is
                                                         browsed

  server.begin();
  Serial.println("HTTP server started");


}

//turns leds on with increasing saturation
```

```
void saturation() {
//response to the client who sent the request saying that their request
   boolean may be false again
  server.send(200, "text/plain", "false");
  ledOn2 = false; //boolean for the leds of client2 is false
  ledOn1 = true;  //boolean for the leds of client1 is true --> client1
                     should turn on lights

  //loop that increases saturation
  Serial.println("Saturation");

    for (r = 0; r < 1001; r = r + INCREASE) {
      analogWrite(redPins[i], r);         //increase red saturation
      analogWrite(greenPins[i], r);       //increase green saturation
      analogWrite(bluePins[i], r);        //increase blue saturation
      delay(FADESPEED);
      i++;        //next pin
      if (i > 2) {
        i = 0;    //one wemos has only 3 led's
      }
    }

//turns leds off again
  for (i = 0; i < 3; i++) {
    analogWrite(redPins[i], LOW);         //turn red off
    analogWrite(greenPins[i], LOW);       //turn green off
    analogWrite(bluePins[i], LOW);        //turn green off
  }
}


void onrequestClient_2() {
  //response to the client who sent the request saying that their request
    boolean may be false again
  server.send(200, "text/plain", "false");
  ledOn2 = true;    //boolean for the leds of client2 is true --> client2
                      should turn on lights
  ledOn1 = false;   //boolean for the leds of client1 is false
}

void connectionClient_1() {
  connectionClient1 = true;   //client1 is connected
  //if client1 can turn on LEDs and is connected, send this response
  if (connectionClient1 && ledOn1) {
   server.send(200, "text/plain", "Client1: Led_on");  //client1 should
                                                          turn on LEDs
    Serial.println("client 1: Led_on");
  }
}

void connectionClient_2() {
  connectionClient2 = true;   //client2 is connected
  //if client2 can turn on LEDs and is connected, send this response
  if (connectionClient2 && ledOn2) {
    server.send(200, "text/plain", "Client2: Led_on");  //client2 should
                                                           turn on LED
    Serial.println("client 2: Led_on");
  }
}
```

```
void loop() {
  server.handleClient();

//prinst in the serial monitor which clients are connected
  if (connectionClient1 && connectionClient2 && !ledOn1 && !ledOn2) {
    Serial.println("Client1: connection & Client2: connection");
  } else if (connectionClient1 && !connectionClient2 && !ledOn1 &&
             !ledOn2) {
    Serial.println("Client1: connection");
  } else if (!connectionClient1 && connectionClient2 && !ledOn1 &&
!ledOn2) {
    Serial.println("Client2: connection");
  }
}
```

4d – Arduino code of client1 Wemos d1 mini in the connection between three Wemos devices

```
/* Jenneke van Beurden - s198889s

   This code is the Client1 code of the loop within the WIFI connection
   of 3 Wemos d1 minis.

   In this code, the loop consists of several steps to turn on the LEDs
   of the Wemos devices:
1) client2 asks the server to turn on LEDs
2) server turns on LEDs and sends to client1 that lights can be turned on
3) client1 turns on LEDs and asks the server to tell client2 to turn on
   the LEDs
4) the server reads this request and sends to client 2 that lights can be
   turned on
5) client2 turns on LEDs and the loop starts at 1 again --> client 2 asks
   the server to turn on LEDs

In order for both clients to receive the correct response sent by the
server, both clients constantly sent request to the server
this request is either to say that they are connected or to ask the
server to turn on the lights of the next Wemos.
The server is regulating which Wemos has to turn on his light Using
booleans saying when to went which response to the Wemos devices.
If the LEDs are on, they will light up in turns with increasing
saturation and
thereafter they will automatically be turned off by the Wemos controlling
these LEDs.

*/

#include <ESP8266WiFi.h>    //wifi library
#include <WiFiClient.h>
const char* host = "192.168.***.**";    //IP address of host

// Network SSID
const char* ssid = "ssid of home netword";
const char* password = "password of home network";

int r, i;
```

```
int redPins[] = {15, 14, 0};      //array for red pins
int greenPins[] = {13, 16, 4};    //array for green pins
int bluePins [] = {12, 2, 5};     //array for blue pins
#define FADESPEED 1000            // make this higher to slow down
#define INCREASE 250              // make this higher to decrease the
saturation loop
bool onrequestClient2 = false;    // boolean for next command

// Use WiFiClient class to create TCP connections
WiFiClient client;
const int httpPort = 80;

void setup() {
  Serial.begin(115200);       // start serial monitor
  delay(10);

  //pinmodes for all the pins are set to 'output'
  for (int i = 0; i < 3; i++) {
    pinMode(redPins[i], OUTPUT);
    pinMode(greenPins[i], OUTPUT);
    pinMode(bluePins[i], OUTPUT);
  }


  //connect to wifi
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

  // Print the IP address
  Serial.print("IP address: ");
  Serial.println(WiFi.localIP());

}

void loop() {

  //connection with host
  Serial.print("connecting to ");
  Serial.println(host);

  // We now create a URI for the request
  String url_onClient2 = "/OnClient2";
  String url_connected = "/connectionClient1";


  //check connection
  if (!client.connect(host, httpPort)) {
    Serial.println("connection failed");
    return;
  //if client is connected but can not send a request yet, let know
    connection succeeded
  } else if (!onrequestClient2) {
    client.print(String("GET ") + url_connected + " HTTP/1.1\r\n" +
                 "Host: " + host + "\r\n" +
```

```
                  "Connection: keep-alive\r\n\r\n");
    delay(10);
    Serial.println("connection succeeded");
  //if client can ask server to turn on the LEDs of client 2, sent that
    request
  } else if (onrequestClient2) {
    client.print(String("GET ") + url_onClient2 + " HTTP/1.1\r\n" +
                  "Host: " + host + "\r\n" +
                  "Connection: keep-alive\r\n\r\n");
    delay(10);
    Serial.println("Connection succeeded: turn client2 on");
  }


  // Read all the lines of the reply from server and print them to Serial
     Monitor etc
  while (client.available()) {
    String line = client.readString();
    Serial.println("Response: " + line);
       if (line.indexOf("Client1: Led_on") > 0 ) { //if servers respons
                                                     is for client 1 to
                                                     turn on LEDs
      saturation();                                //client one turns on
                                                     LEDs
      onrequestClient2 = true;                     //request boolean is true
                                                     --> ask server to tell
                                                     client 2 to turn on
                                                     lights
     //if the response of the server is 'false' the request boolean is
       false
    } else if (line.indexOf("false") > 0) {
      onrequestClient2 = false;
    }
  }
}

//turns leds on with increasing saturation
void saturation() {
   //loop that increases saturation
    Serial.println("Saturation");
    for (r = 0; r < 1001; r = r + INCREASE) {
     analogWrite(redPins[i], r);          //increase red saturation
     analogWrite(greenPins[i], r);        //increase green saturation
     analogWrite(bluePins[i], r);         //increase blue saturation
     delay(FADESPEED);
     i++;         //next pin
     if (i > 2) {
       i = 0;     //one wemos has only 3 led's
     }
    }

//turns leds off again
  for (i = 0; i < 3; i++) {
    analogWrite(redPins[i], LOW);          //turn red off
    analogWrite(greenPins[i], LOW);        //turn green off
    analogWrite(bluePins[i], LOW);         //turn green off
  }


}
```

4e – Arduino code of client2 Wemos d1 mini in the connection between three Wemos devices

```
/* Jenneke van Beurden - s198889s

    This code is the Client2 code of the loop within the WIFI connection
     of 3 Wemos d1 minis.

   In this code, the loop consists of several steps to turn on the LEDs
   of the Wemos devices:
1) client2 asks the server to turn on LEDs
2) server turns on LEDs and sends to client1 that lights can be turned on
3) client1 turns on LEDs and asks the server to tell client2 to turn on
   the LEDs
4) the server reads this request and sends to client 2 that lights can be
   turned on
5) client2 turns on LEDs and the loop starts at 1 again --> client 2 asks
   the server to turn on LEDs

In order for both clients to receive the correct response sent by the
server, both clients constantly sent request to the server
this request is either to say that they are connected or to ask the
server to turn on the lights of the next Wemos.
The server is regulating which Wemos has to turn on his light Using
booleans saying when to went which response to the Wemos devices.
If the LEDs are on, they will light up in turns with increasing
saturation and
thereafter they will automatically be turned off by the Wemos controlling
these LEDs.

*/

#include <ESP8266WiFi.h>    //wifi library
#include <WiFiClient.h>
const char* host = "192.168.***.**";    //IP address of host

// Network SSID
const char* ssid = "ssid of home netword";
const char* password = "password of home network";

int r, i;
int redPins[] = {15, 14, 0};      //array for red pins
int greenPins[] = {13, 16, 4};    //array for green pins
int bluePins [] = {12, 2, 5};     //array for blue pins
#define FADESPEED 1000            // make this higher to slow down
#define INCREASE 250              // make this higher to decrease the
saturation loop
bool onrequestServer = true;      // boolean for next command

// Use WiFiClient class to create TCP connections
WiFiClient client;
const int httpPort = 80;

void setup() {
  Serial.begin(115200);      // start serial monitor
  delay(10);

  //pinmodes for all the pins are set to 'output'
```

```
  for (int i = 0; i < 3; i++) {
    pinMode(redPins[i], OUTPUT);
    pinMode(greenPins[i], OUTPUT);
    pinMode(bluePins[i], OUTPUT);
  }


  //connect to wifi
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

  // Print the IP address
  Serial.print("IP address: ");
  Serial.println(WiFi.localIP());
}

void loop() {
  //connection with host
  Serial.print("connecting to ");
  Serial.println(host);

  // create a URI for the request
  String url_on = "/OnServer";
  String url_connected = "/connectionClient2";

  //check connection
  if (!client.connect(host, httpPort)) {
    Serial.println("connection failed");
    return;
    //if client is connected but can not send a request yet, let know
      connection succeeded
  } else if (!onrequestServer) {
    client.print(String("GET ") + url_connected + " HTTP/1.1\r\n" +
                 "Host: " + host + "\r\n" +
                 "Connection: keep-alive\r\n\r\n");
    delay(10);
    Serial.println("connection succeeded");
    //if client can ask server to turn on its LEDs, sent that request
  } else if (onrequestServer) {
    client.print(String("GET ") + url_on + " HTTP/1.1\r\n" +
                 "Host: " + host + "\r\n" +
                 "Connection: keep-alive\r\n\r\n");
    delay(50);
    Serial.println("connection succeeded: Turn server on");
  }

  // Read all the lines of the reply from server and print them to Serial
     Monitor etc
  while (client.available()) {
    String line = client.readString();
    Serial.print("Response: ");
    Serial.println(line);
    if (line.indexOf("Client2: Led_on") > 0) {
      saturation();
```

```
      onrequestServer = true;
    } else if (line.indexOf("false") > 0) {
      onrequestServer = false;
    }
  }
}

//turns leds on with increasing saturation
void saturation() {
  //loop that increases saturation
  Serial.println("Saturation");
  for (r = 0; r < 1001; r = r + INCREASE) {
    analogWrite(redPins[i], r);         //increase red saturation
    analogWrite(greenPins[i], r);       //increase green saturation
    analogWrite(bluePins[i], r);        //increase blue saturation
    delay(FADESPEED);
    i++;        //next pin
    if (i > 2) {
      i = 0;    //one wemos has only 3 led's
    }
  }

//turns leds off again
  for (i = 0; i < 3; i++) {
    analogWrite(redPins[i], LOW);         //turn red off
    analogWrite(greenPins[i], LOW);       //turn green off
    analogWrite(bluePins[i], LOW);        //turn green off
  }
}
```

Appendix 5 – Arduino code of ten RGB-LEDs controlled via an Arduino Uno and two 74HC4067 Multiplexers

```
/*Jenneke van Beurden - s1988891

  This code is written to control 10 RGB-LEDs using two multiplexers
 (74HC4067)
  It is now written to turn on all of the output pins of the multiplexers
   that are connected to a RGB-LED, but this code was mainly used to test
   how the multiplexers work
 */

#include <Type4067Mux.h>  //multiplexer library

// Mux declared with analog input signal on pins 11 for mux1 and A1 for
mux2 and channel control on digital pins 10, 9, 8 & 7 for mux1 and
channel control on pins A5. A4, A3 and A2 for mux2
Type4067Mux mux1(11, OUTPUT, ANALOG, 10, 9, 8, 7);
Type4067Mux mux2(A1, OUTPUT, ANALOG, A5, A4, A3, A2);

const int redPins[] = {1, 4, 7, 10, 13};     //array for red pins
const int greenPins[] = {2, 5, 8, 11, 14};   //array for green pins
const int bluePins [] = {3, 6, 9, 12, 15};    //array for blue pins
#define FADESPEED 1          // make this higher to slow down
#define INCREASE 85          // make this higher to decrease the
saturation loop
int r, i = 0;

void setup() {
}

void loop() {
//turns all the pins on
  for (int i = 0; i < 5; i++) {
    mux1.write(500, redPins[i]);
    mux1.write(500, greenPins[i]);
    mux1.write(500, bluePins[i]);
    mux2.write(500, redPins[i]);
    mux2.write(500, greenPins[i]);
    mux2.write(500, bluePins[i]);
  }
}
```

Appendix 6 – Arduino code of ten RGB-LEDs controlled via an Arduino Uno and two TLC5940 LED drivers

```
/*Jenneke van Beurden - s1988891

  This is code of TLC5940 Led Driver

  This code can turn all ten LEDs on in different color patterns:
  1) turn leds on in turns with increasing brightness
  2) turn leds green, some will randomly be yellow or blue
  3) turn leds purple, some will randomly be blue or red
  4) turns leds on in random groups of the same colour (Red, Green &
     Blue)
  5) turns leds on in random groups of the same colour (Aqua, Yellow &
     Purple)
  6) turns all leds on in the color white
  7) turns all leds on in a different color
 */

#include "Tlc5940.h"

const int redPins[] = {1, 4, 7, 10, 13, 16, 19, 22, 25, 28};     //array
                                                                  for red pins
const int greenPins[] = {2, 5, 8, 11, 14, 17, 20, 23, 26, 29};   //array
                                                                 for green pins
const int bluePins [] = {3, 6, 9, 12, 15, 18, 21, 24, 27, 30};    //array
                                                                  for blue pins
const int buttonPin = 2;
#define FADESPEED 1000         // make this higher to slow down
#define INCREASE 99           // make this higher to decrease the
saturation loop
int s, i, f, r, g, b, n;
int duration = 0;
int changeSetting = 0;
int on = 255;

void setup() {
  Serial.begin(9600);

  Tlc.init();
}

void loop() {

  saturation();             //turn leds on in turns with increasing
brightness
  greenTempo();             //turn leds green, some will randomly be
yellow or blue
  purpleTempo();            //turn leds purple, some will randomly be
blue or red
  scenarioSyncGroupsRGB();  //turns leds on in random groups of the same
colour (Red, Green & Blue)
  scenarioSyncGroupsAYP();  //turns leds on in random groups of the same
colour (Aqua, Yellow & Purple)
  white();                  //turns all leds on in the color white
  multicolor();             //turns all leds on in a different color
}

void white() {
  for (i = 0; i < 10; i++) {
```

```
    Tlc.set(redPins[i], 200);
    Tlc.set(redPins[9], 400);
    Tlc.set(redPins[8], 350);
    Tlc.set(redPins[7], 400);
    Tlc.set(greenPins[i], 200);
    Tlc.set(bluePins[i], 200);
    Tlc.set(bluePins[0], 300);
    Tlc.set(bluePins[3], 225);
    Tlc.set(greenPins[2], 450);
    Tlc.update();
  }
}

void multicolor() {
  // white
  Tlc.set(redPins[0], 200);
  Tlc.set(greenPins[0], 200);
  Tlc.set(bluePins[0], 200);

  //yellow
  Tlc.set(redPins[1], 200);
  Tlc.set(greenPins[1], 200);

  //purple
  Tlc.set(redPins[2], 200);
  Tlc.set(bluePins[2], 200);

  //aqua
  Tlc.set(greenPins[3], 200);
  Tlc.set(bluePins[3], 200);

  //red
  Tlc.set(redPins[4], 200);

  //blue
  Tlc.set(bluePins[5], 200);

  //green
  Tlc.set(greenPins[6], 200);

  //orange
  Tlc.set(redPins[7], 255);
  Tlc.set(greenPins[7], 55);

  //dark purple
  Tlc.set(redPins[8], 170);
  Tlc.set(bluePins[8], 255);


  //dark light green
  Tlc.set(greenPins[9], 300);
  Tlc.set(bluePins[9], 40);
  Tlc.update();

}

void saturation() {
  int maxVal = random(200, 2000);

  for (s = 20; s < maxVal; s = s + INCREASE) {
    if (i == 2) {
```

```
      Tlc.set(redPins[i], s);
      Tlc.set(greenPins[i], s * 2);
      Tlc.set(bluePins[i], s);
      i++;
      Tlc.update();
    } else {
      Tlc.set(redPins[i], s);
      Tlc.set(greenPins[i], s);
      Tlc.set(bluePins[i], s);
      i++;
      Tlc.update();
    }
    if (i > 9) {
      i = 0;
    }
    delay(FADESPEED);
  }

  Tlc.clear();

  if (i == 2) {
    Tlc.set(redPins[i], 0);
    Tlc.set(greenPins[i], 0);
    Tlc.set(bluePins[i], 0);
    Tlc.update();
    delay(500);
    Tlc.set(redPins[i], 100);
    Tlc.set(greenPins[i], 200);
    Tlc.set(bluePins[i], 100);
    Tlc.update();
    delay(500);
    Tlc.clear();
    Tlc.set(redPins[i], 0);
    Tlc.set(greenPins[i], 0);
    Tlc.set(bluePins[i], 0);
    Tlc.update();
    delay(500);
    Tlc.set(redPins[i], 100);
    Tlc.set(greenPins[i], 200);
    Tlc.set(bluePins[i], 100);
    Tlc.update();
    delay(500);
    Tlc.clear();
    Tlc.set(redPins[i], 0);
    Tlc.set(greenPins[i], 0);
    Tlc.set(bluePins[i], 0);
    Tlc.update();
    delay(500);
    Tlc.set(redPins[i], 100);
    Tlc.set(greenPins[i], 200);
    Tlc.set(bluePins[i], 100);
    Tlc.update();
    delay(500);
  } else {
    Tlc.set(redPins[i], 0);
    Tlc.set(greenPins[i], 0);
    Tlc.set(bluePins[i], 0);
    Tlc.update();
    delay(500);
    Tlc.set(redPins[i], 100);
    Tlc.set(greenPins[i], 100);
```

```
    Tlc.set(bluePins[i], 100);
    Tlc.update();
    delay(500);
    Tlc.clear();
    Tlc.set(redPins[i], 0);
    Tlc.set(greenPins[i], 0);
    Tlc.set(bluePins[i], 0);
    Tlc.update();
    delay(500);
    Tlc.set(redPins[i], 100);
    Tlc.set(greenPins[i], 100);
    Tlc.set(bluePins[i], 100);
    Tlc.update();
    delay(500);
    Tlc.clear();
    Tlc.set(redPins[i], 0);
    Tlc.set(greenPins[i], 0);
    Tlc.set(bluePins[i], 0);
    Tlc.update();
    delay(500);
    Tlc.set(redPins[i], 100);
    Tlc.set(greenPins[i], 100);
    Tlc.set(bluePins[i], 100);
    Tlc.update();
    delay(500);
  }


}

void greenTempo() {
  int randomRed1 = random(10);
  int randomBlue1 = random(10);
  int randomRed2 = random(10);
  int randomBlue2 = random(10);

  if (randomRed1 != randomRed2 && randomBlue1 != randomBlue2 &&
randomRed1 != randomBlue1 && randomRed2 != randomBlue2 && randomRed1 !=
randomBlue2 && randomRed2 != randomBlue1) {
    for (f = 0; f < 256; f++) {
      Tlc.set(redPins[randomRed1], f);
      Tlc.set(bluePins[randomBlue1], f);
      delay(25);
      Tlc.update();
      for (i = 0; i < 10; i++) {
        Tlc.set(greenPins[i], 255);
        Tlc.update();
      }
    }
    for (f = 0; f < 256; f++) {
      Tlc.set(redPins[randomRed2], f);
      Tlc.set(bluePins[randomBlue2], f);
      delay(25);
      Tlc.update();
      for (i = 0; i < 10; i++) {
        Tlc.set(greenPins[i], 255);
        Tlc.update();
      }
    }
    for (f = 255; f > 0; f--) {
      Tlc.set(redPins[randomRed1], f);
```

```
      Tlc.set(bluePins[randomBlue1], f);
      delay(25);
      Tlc.update();
      for (i = 0; i < 10; i++) {
        Tlc.set(greenPins[i], 255);
        Tlc.update();
      }
    }
    for (f = 255; f > 0; f--) {
      Tlc.set(redPins[randomRed2], f);
      Tlc.set(bluePins[randomBlue2], f);
      delay(25);
      Tlc.update();
      for (i = 0; i < 10; i++) {
        Tlc.set(greenPins[i], 255);
        Tlc.update();
      }
    }
  }
}

void purpleTempo() {
  int randomRed1 = random(10);
  int randomBlue1 = random(10);
  int randomRed2 = random(10);
  int randomBlue2 = random(10);

  if (randomRed1 != randomRed2 && randomBlue1 != randomBlue2 &&
randomRed1 != randomBlue1 && randomRed2 != randomBlue2 && randomRed1 !=
randomBlue2 && randomRed2 != randomBlue1) {

    for (i = 0; i < 10; i++) {
      Tlc.set(redPins[i], 255);
      Tlc.set(bluePins[i], 255);
      Tlc.update();
    }
    for (f = 256; f > 0; f--) {
      Tlc.set(bluePins[randomBlue1], f);
      Tlc.set(redPins[randomRed1], f);
      delay(25);
      Tlc.update();
    }
    for (f = 256; f > 0; f--) {
      Tlc.set(bluePins[randomBlue2], f);
      Tlc.set(redPins[randomRed2], f);
      delay(25);
      Tlc.update();
    }
    for (f = 0; f < 256; f++) {
      Tlc.set(bluePins[randomBlue1], f);
      Tlc.set(redPins[randomRed1], f);
      delay(25);
      Tlc.update();
    }
    for (f = 0; f < 256; f++) {
      Tlc.set(bluePins[randomBlue2], f);
      Tlc.set(redPins[randomRed2], f);
      delay(25);
      Tlc.update();
    }
  }
```

```
}

void scenarioSyncGroupsRGB() {
  int maxRed = random(2, 4);
  int maxGreen = random(maxRed + 2, 8);
  int maxBlue = random(maxGreen + 2, 11);

  int randomNumber[] = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9};
  const int questionCount = sizeof randomNumber / sizeof randomNumber[0];
  for (int i = 0; i < questionCount; i++) {
    int n = random(0, questionCount);  // Integer from 0 to
questionCount-1
    int temp = randomNumber[n];
    randomNumber[n] =  randomNumber[i];
    randomNumber[i] = temp;
  }

  for (i = 0; i < 10; i++) {
    Tlc.set(redPins[i], 200);
    Tlc.set(redPins[9], 400);
    Tlc.set(redPins[8], 350);
    Tlc.set(redPins[7], 400);
    Tlc.set(greenPins[i], 200);
    Tlc.set(bluePins[i], 200);
    Tlc.set(bluePins[0], 300);
    Tlc.set(bluePins[3], 225);
    Tlc.set(greenPins[2], 450);
    Tlc.update();
  }

  for (f = 256; f > 0; f--) {
    for (n = 0; n < maxRed; n++) {
      Tlc.set(greenPins[randomNumber[n]], f);
      Tlc.set(bluePins[randomNumber[n]], f);
    }
    for (n = maxRed; n < maxGreen; n++) {
      Tlc.set(redPins[randomNumber[n]], f);
      Tlc.set(bluePins[randomNumber[n]], f);
    }
    for (n = maxGreen; n < maxBlue; n++) {
      Tlc.set(redPins[randomNumber[n]], f);
      Tlc.set(greenPins[randomNumber[n]], f);
    }
    delay(25);
    Tlc.update();
  }
  delay(3000);
  for (f = 0; f < 256; f++) {
    for (n = 0; n < maxRed; n++) {
      Tlc.set(greenPins[randomNumber[n]], f);
      Tlc.set(bluePins[randomNumber[n]], f);
    }
    for (n = maxRed; n < maxGreen; n++) {
      Tlc.set(redPins[randomNumber[n]], f);
      Tlc.set(bluePins[randomNumber[n]], f);
    }
    for (n = maxGreen; n < maxBlue; n++) {
      Tlc.set(redPins[randomNumber[n]], f);
      Tlc.set(greenPins[randomNumber[n]], f);
    }
    delay(25);
```

```
    Tlc.update();
  }
}

void scenarioSyncGroupsAYP() {
  int maxRed = random(2, 4);
  int maxGreen = random(maxRed + 2, 8);
  int maxBlue = random(maxGreen + 2, 11);

  int randomNumber[] = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9};
  const int questionCount = sizeof randomNumber / sizeof randomNumber[0];
  for (int i = 0; i < questionCount; i++) {
    int n = random(0, questionCount);  // Integer from 0 to
questionCount-1
    int temp = randomNumber[n];
    randomNumber[n] =  randomNumber[i];
    randomNumber[i] = temp;
  }

  for (i = 0; i < 10; i++) {
    Tlc.set(redPins[i], 200);
    Tlc.set(redPins[9], 400);
    Tlc.set(redPins[8], 350);
    Tlc.set(redPins[7], 400);
    Tlc.set(greenPins[i], 200);
    Tlc.set(bluePins[i], 200);
    Tlc.set(bluePins[0], 300);
    Tlc.set(bluePins[3], 225);
    Tlc.set(greenPins[2], 450);
    Tlc.update();
  }

  for (f = 300; f > 0; f--) {
    for (n = 0; n < maxRed; n++) {
      Tlc.set(greenPins[randomNumber[n]], f);
    }
    for (n = maxRed; n < maxGreen; n++) {
      Tlc.set(redPins[randomNumber[n]], f);
    }
    for (n = maxGreen; n < maxBlue; n++) {
      Tlc.set(bluePins[randomNumber[n]], f);
    }
    delay(25);
    Tlc.update();
  }
  delay(3000);
  for (f = 0; f < 300; f++) {
    for (n = 0; n < maxRed; n++) {
      Tlc.set(greenPins[randomNumber[n]], f);
    }
    for (n = maxRed; n < maxGreen; n++) {
      Tlc.set(redPins[randomNumber[n]], f);
    }
    for (n = maxGreen; n < maxBlue; n++) {
      Tlc.set(bluePins[randomNumber[n]], f);
    }
    delay(25);
    Tlc.update();
  }
}
```

Appendix 7 – User test forms

7a – Blank interview form

Age:

Sex:

Pabo student year:

1. **<u>Saturation:</u>**

De hele groep speelt samen een ritme, maar een slag van het ritme mag maar geslagen worden door alleen de leerling die aan de beurt is. De leerlingen zullen dus goed op moeten letten om op het juiste moment een slag te slaan.

video bekijken https://youtu.be/JUKoB-fjAcQ

1.1 Wat denk jij over deze feedback?

1.2 Welke leerling slaat op het verkeerde ritme?

Het idee is dat zolang het ritme goed gespeeld wordt, de lampjes steeds feller worden. Zodra er een verkeerde slag geslagen is, zal die persoon opnieuw moeten beginnen.

1.3 Wat denk je nu over deze feedback?

1.4 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

1.5 Hoe zou de feedback verbeterd kunnen worden?

2. **Tempo:**

Elke leerling speelt een bepaald ritme, tegelijkertijd. Dit kan een ritme zijn wat de docent speelt, van een bestaand nummer etc. Sommige leerlingen spelen te langzaam, anderen te snel.

video bekijken https://youtu.be/BgvubFNG2PU

2.1 Wat denk jij over deze feedback?

2.2 Welke leerling slaat op het verkeerde ritme? Welke te snel en welke te langzaam

Het idee is dat groen de 'juiste' kleur is, want dat is een mengsel van geel en blauw. Als er een leerling te lanzaam of te snel gaat veranderd het instrument naar geel of blauw.

2.3 Wat denk je nu over deze feedback?

2.4 Welke kleur (geel of blauw) zou snel moeten zijn en welke langzaam?

2.5 Stel er zouden meer leerlingen zijn die te langzaam of te snel spelen, zou je dan nog steeds overzicht hebben?

2.6 Hoe zou de feedback verbeterd kunnen worden?

Zelfde situatie met paars, blauw en rood https://youtu.be/hqBI-HUuJP4

2.7 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

2.8 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

3. **<u>Syncing:</u>**

Elke leerling speelt een bepaald ritme en sommige kunnen (per ongeluk of expres) hetzelfde ritme spelen.

video bekijken https://youtu.be/RwYheuaxCII

3.1 Wat denk jij over deze feedback?

3.2 Welke leerlingen spelen hetzelfde ritme?

Het idee is dat dezelfde kleuren hetzelfde ritme spelen, behalve wit want wit betekent dat je een origineel ritme speelt.

3.3 Wat denk je nu over deze feedback?

3.4 Welke leerlingen spelen een origineel ritme? Is dit duidelijk?

3.5 Kun je goed de verschillende kleuren onderscheiden

3.6 Welke oefeningen zou je kunnen doen mbv deze feedback?

3.7 Hoe zou de feedback de docent in zo'n oefening kunnen ondersteunen?

3.8 Hoe denk jij over de volgende oefeningen met deze feedback? Hoe ziet de feedback er uit, zou het ondersteunend zijn, hoe zie jij die oefening voor je?

a. **speel hetzelfde ritme als..... de docent, een klasgenoot, de heleklas, de klasgenoot tegenover je**
b. **speel een kanon of meerstemmig**
c. **zoek iemand die.... hetzelfde ritme speelt**
d. **speel allemaal een ander ritme**

3.9 Hoe zou de feedback verbeterd kunnen worden?

3.10 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Zelfde situatie met paars, aqua en geel https://youtu.be/C0r1s-9M79I

3.11 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

3.12 Hoeveel kleuren zouden we kunnen/moeten gebruiken?

3.13 Welke kleuren zijn goed van elkaar te onderscheiden?

4. <u>Foto van verschillende kleurtjes</u>

4.1 Welke zijn goed van elkaar te onderscheiden? (ooghoeken, is dat nodig?)

4.2 Waar zou je nog meer de kleurtjes voor kunnen gebruiken?

4.3 Hoe denk je over deze manier van feedback (lichtgevende instrumenten)? Zou het van toegevoegde waarde kunnen zijn?

Hoe zou je het nog meer in kunnen zetten tijdens een muziek les over ritme?

Nog meer (algemene) opmerkingen?

7b – Information Brochure 'Digitale technologie bij muziekonderwijs'

Informatiefolder onderzoek in de klas *'digitale technologie bij muziekonderwijs'* Universiteit Twente

Human Media Interaction Benno Spieker MA, doctoraal student ***@utwente.nl
Technologie voor het muziekonderwijs van de toekomst

Deze brochure gaat over deelname aan een onderzoek van Universiteit Twente en Gent Universiteit waarvoor je je hebt opgegeven.

In deze brochure lees je hierover meer informatie. De informatie helpt je te beslissen of je mee wilt doen. Het onderzoek wordt geleid door Benno Spieker. Als iets niet duidelijk is, kun je hem altijd om extra uitleg vragen. De contactgegevens staan hierboven.
Onderwijs is altijd in ontwikkeling. Er komt steeds meer aandacht voor muziekonderwijs en digitale leermiddelen die het leren van kinderen kan ondersteunen. Bij de Universiteit Twente doen we hier onderzoek naar, met onderzoekers in interactieve technologie en muziekonderwijs.

Voor dit onderzoek organiseren we leeractiviteiten op (hoge)scholen, waarbij onder andere gebruik wordt gemaakt van digitale technologie. Tijdens deze activiteiten evalueren we hoe kinderen, studenten en/of (vak)leerkrachten werken met de nieuwe technologie. Dit doen we met behulp van vragenlijsten, interviews en observaties van de deelnemers tijdens de activiteit. De (hoge)school en de deelnemers maken zo kennis met nieuwe vormen van onderwijs. Voor ons, de onderzoekers van de Universiteit Twente, levert dit waardevolle inzichten op, waarmee toepassingen van technologie verder ontwikkeld kunnen worden. Het onderzoek richt zich dus niet specifiek op jou als deelnemer, maar vooral op het verkennen van de mogelijkheden van de technologie in het muziekonderwijs.

Je hebt aangegeven te willen deelnemen aan dit onderzoek, bijvoorbeeld door het invullen van een vragenlijst of deel te nemen aan een interview. In deze folder leggen we uit wat dit voor jou als deelnemer betekent, hoe je mee kunt doen aan deze activiteiten, en welke basis-spelregels we samen hanteren. Je beslist zelf of je meedoet aan de onderzoeksactiviteiten.
Contactgegevens onderzoeksgroep: Human Media Interaction Dennis Reidsma ***@utwente.nl

Lees de folder rustig door voordat je beslist of je wilt meedoen. Als je vragen hebt kun je contact opnemen met Benno Spieker (contactgegevens: zie linker kolom).

V1.0 – Mei 2019

Onderzoeksactiviteiten van Universiteit Twente: Hoe werkt het?

Voor sommige onderzoeken wordt aan deelnemers gevraagd om mee te doen aan onderzoeksactiviteiten. Je geeft jouw toestemming door het bijgevoegde toestemmingsformulier in te vullen en te ondertekenen.

De toestemming geldt voor de periode dat het onderzoek loopt. Als je in de loop van deze periode van mening verandert kun je jouw toestemming ook weer intrekken. Je wordt gedurende de periode op de hoogte gehouden van de stappen in de onderzoeksactiviteit.

Is het verplicht om mee te doen? Je doet niet mee zonder jouw toestemming. Je beslist zelf over jouw deelname aan het onderzoek. Als je besluit niet mee te doen, hoef je verder niets te doen. Je hoeft niets te tekenen. Je hoeft ook niet te zeggen waarom je niet wilt meedoen.

Wat gebeurt er tijdens de onderzoeksactiviteiten? Je wordt gevraagd om een vragenlijst in te vullen met vragen over jouw kennis en ervaring met technologie in het (muziek)onderwijs, aangevuld met algemene vragen die gaan over de context waarin je muziekles geeft. Als je bij de werving hebt aangegeven dat je ook geïnterviewd mag worden, dan wordt een datum gepland waarop je (waar mogelijk) in een kleine groep antwoord geeft bij vragen van de onderzoekers. Door jouw antwoorden krijgen we een goed beeld van wat nodig is met betrekking tot de technologie die we door middel van ons onderzoek gaan ontwikkelen.
Wie verzint en begeleidt de onderzoeksactiviteiten? De vragenlijsten zijn ontworpen op basis van bestaande vragenlijsten, aangevuld met door ons ontworpen vragen. Je vult de vragenlijsten individueel en zelfstandig in. Het interview zal worden (be)geleid door de onderzoeker.

Welke gegevens worden er verzameld? De vragenlijst bestaat uit vier delen. Het eerste deel zijn algemene vragen over de context waarin je muziekles geeft. Het tweede deel is gericht op de technologie die je momenteel toepast. Het derde deel is gericht op jouw ideeën en ervaringen ten aanzien van het gebruiken van technologie voor het muziekonderwijs. Het bestaat uit stellingen uit een internationale vragenlijst die zijn vertaald naar het Nederlands. Het laatste deel is gericht op jouw kennis ten aanzien van de drie kennisgebieden, onderwijs, muziek en technologie. De gegevens worden zo anoniem mogelijk verwerkt en bewaard. In het databestand worden alleen identificatienummers gebruikt. Deze nummers zijn in een apart document gekoppeld aan de namen van de deelnemers en worden gedurende het onderzoeksproject op een aparte plek bewaard en daarna verwijderd. De onderzoeksgegevens worden conform de richtlijnen van de VNSU minimaal 10 jaar bewaard.

Wie kan de vragenlijsten inzien? De vragenlijsten zijn enkel toegankelijk voor mensen die betrokken zijn bij dit onderzoeksprogramma. Een lijst met namen van mensen die toegang hebben tot het materiaal is beschikbaar en kan worden opgevraagd bij de onderzoeker, Benno Spieker. De door jou ingevulde antwoorden zullen absoluut niet publiek beschikbaar gemaakt worden of gebruikt worden voor reclame- en communicatiedoeleinden.
antwoorden zullen absoluut niet publiek beschikbaar gemaakt worden of gebruikt worden voor reclame- en communicatiedoeleinden.

Kan je jouw toestemming ongedaan maken? Natuurlijk! Als je aan het begin van de onderzoeks- periode toestemming hebt gegeven, maar je wilt niet meer meedoen aan deze activiteiten, dan kan je dat doorgeven aan Benno Spieker. Je zal dan niet meer meedoen aan de (rest van) de activiteit(en).
Kan je jouw toestemming ongedaan maken? Natuurlijk! Als je aan het begin van de onderzoeks- periode toestemming hebt gegeven, maar je wilt niet meer meedoen aan deze activiteiten, dan kan je dat doorgeven aan Benno Spieker. Je zal dan niet meer meedoen aan de (rest van) de activiteit(en).
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Wie krijgen informatie over de resultaten? De universiteit zal de onderzoeksresultaten openbaar maken, onder andere als onderdeel van een publicatie. Daarnaast is het ook mogelijk contact op te nemen met de onderzoekers en te vragen om de resultaten. Deze zullen jou dan worden toegestuurd. Tijdens het interview kun je de aanwezige onderzoekers aanspreken met vragen over het onderzoek.

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Meer informatie en onafhankelijk advies. Wil je graag een onafhankelijk advies over meedoen aan dit onderzoek, of een klacht indienen, dan kun je terecht bij de secretaris van de Ethische Commissie (ethics- comm-ewi@utwente.nl). De commissie bestaat uit onafhankelijk deskundigen van de universiteit en is beschikbaar voor vragen en klachten rondom het onderzoek.

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Voor overige vragen kun je terecht bij de onderzoekers van de universiteit.

Voor overige vragen kun je terecht bij de onderzoekers van de universiteit.

7c – Toestemmingsforulier (consent form)

Toestemmingsformulier

Betreft: Toestemming voor deelname aan activiteiten Vragenlijst en (groeps)interview/expertgroep in het kader van het onderzoek naar *'digitale technologie bij muziekonderwijs'* van de Universiteit Twente.

Als u akkoord gaat kunt u hieronder aankruisen dat u toestemming geeft. Vervolgend kunt u de verdere gegevens invullen en het formulier ondertekenen.

Ik ben over dit onderzoek volledig geïnformeerd en verklaar dat ik 18 jaar of ouder ben en vrijwillig aan dit onderzoek deelneem. Ik geef toestemming voor het verzamelen van geanonimiseerde onderzoeksmaterialen zoals beschreven in de bijbehorende informatiefolder. Ik geef ook toestemming voor het maken van audio-opnames voor onderzoek en evaluatie bij eventuele deelname aan het interview. De audio-opnames worden enkel door betrokken onderzoekers beluisterd. In het geval de betrokken

onderzoekers de audio-opnames publiek willen maken of laten horen aan derden voor demonstratie of rapportage, dan wordt u daarvoor eerst om toestemming gevraagd. ☐

Uw naam ……

Datum……

Handtekening:

……

Contact informatie

Mocht u vragen hebben over dit onderzoek dan kunt u contact opnemen met de onderzoeker: Benno Spieker (***@utwente.nl). Voor meer informatie: zie de informatiefolder bij dit formulier**.**

Appendix 8 – User test participant results

8a – Interview participant 1

Age: 21

Sex: vrouw

Pabo student year: 3

1. **Saturation:**

De hele groep speelt samen een ritme, maar een slag van het ritme mag maar geslagen worden door alleen de leerling die aan de beurt is. De leerlingen zullen dus goed op moeten letten om op het juiste moment een slag te slaan.

video bekijken https://youtu.be/JUKoB-fjAcQ

1.1 Wat denk jij over deze feedback?

Als de lichtjes branden heeft het kind op tijd geslagen, hoe feller de lichtjes, hoe harder er geslagen wordt. Kipperende lichtjes betekenen dat het fout gaat, het kind kan daarna opnieuw beginnen.

1.2 Welke leerling slaat op het verkeerde ritme?

De leering met zwart haar en groen shirt, want daar knippert het lampje van

Het idee is dat zolang het ritme goed gespeeld wordt, de lampjes steeds feller worden. Zodra er een verkeerde slag geslagen is, zal die persoon opnieuw moeten beginnen.

1.3 Wat denk je nu over deze feedback?

Er wordt niet gefocussed op dynamiek, daar zou je nog rekening mee kunnen houden

1.4 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Ze zullen enthousiast zijn, maar moet goed uitgelegd worden

1.5 Hoe zou de feedback verbeterd kunnen worden?

Weet ik eigenlijk niet

2. **<u>Tempo:</u>**

Elke leerling speelt een bepaald ritme, tegelijkertijd. Dit kan een ritme zijn wat de docent speelt, van een bestaand nummer etc. Sommige leerlingen spelen te langzaam, anderen te snel.

video bekijken https://youtu.be/BgvubFNG2PU

2.1 Wat denk jij over deze feedback?

Ik denk dat het de bedoeling is dat als je uit het rime gaat het instrument of blauw of rood wordt, wat wat is is niet duidelijk, als het weer paars wordt gaat het weer goed

2.2 Welke leerling slaat op het verkeerde ritme? Welke te snel en welke te langzaam

Ik zou zeggen blauw te langzaam en rood te snel. Ondanks dat niet gelijk duidelijk is welke kleur wat betekend is wel te zien dat er iets fout gaat

Het idee is dat groen de 'juiste' kleur is, want dat is een mengsel van geel en blauw. Als er een leerling te lanzaam of te snel gaat veranderd het instrument naar geel of blauw.

2.3 Wat denk je nu over deze feedback?

Is al besproken binnen 2.1

2.4 Welke kleur (geel of blauw) zou snel moeten zijn en welke langzaam?

Niet besproken

2.5 Stel er zouden meer leerlingen zijn die te langzaam of te snel spelen, zou je dan nog steeds overzicht hebben?

Ik denk dat het wel duidelijk is want door de kleuren kan je ze groeperen in wie te snel en wie te langzaam speelt. Het ligt ook aan de docent of het duidelijk is of niet. Een mogenlijkheid om het voor de docent makkelijker te maken of om het instrument te gebruiken is om eventueel de leerlingen in groepjes uit elkaar halen

2.6 Hoe zou de feedback verbeterd kunnen worden?

Duidelijker kleurverschil, maar is niet in een keer duidelijk wat snel is en wat langzaam. Daarom zal er instructe nodig zijn daarover.

Zelfde situatie met paars, blauw en rood https://youtu.be/hqBI-HUuJP4

2.7 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

Op de video is de paarse duidelijker. Rood en blauw zijn meer contrast kleuren, dus dat zou meer duidelijkheid geven.

2.8 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Ik denk dat ze het heel leuk vinden, stel er is 1 kind die het fout doet is dat onveilig. Pas op voor faalangst. Een leuke nieuwe opdracht is ‘zoek uit wat de lampjes betekenen: wat betekend rood en wat blauw?’ de kinderen wordt van te voren niet verteld wat het betekend

3. <u>Syncing:</u>

Elke leerling speelt een bepaald ritme en sommige kunnen (per ongeluk of expres) hetzelfde ritme spelen.

video bekijken https://youtu.be/RwYheuaxCII

3.1 Wat denk jij over deze feedback?

Deze is het vaagst, ik weet niet wanneer het wel of niet goed gaat.

3.2 Welke leerlingen spelen hetzelfde ritme?

De groene spelen hetzelfde en de rode en de blauwe, wat wit betekent is niet duidelijk

Het idee is dat dezelfde kleuren hetzelfde ritme spelen, behalve wit want wit betekent dat je een origineel ritme speelt.

3.3 Wat denk je nu over deze feedback?

Er is duidelijke instructie nodig, zeker voor het witte ritme. De witte zijn niet exact dezelfde kleur wit, maar met instructie is dit voor de docent duidelijk genoeg

3.4 Welke leerlingen spelen een origineel ritme? Is dit duidelijk?

Is al besproken in 3.3

3.5 Kun je goed de verschillende kleuren onderscheiden

De kleuren zijn duidelijk in beide filmpjes

3.6 Welke oefeningen zou je kunnen doen mbv deze feedback?

Een les focussen op ritme, bijvoorbeel in groep 8 kan je een les over continenten geven over hoe de muziek op die continenten is. Ook zou je verschillende ritmes aan een continent kunnen geven en zo de ritmes van de continenten spelen

3.7 Hoe zou de feedback de docent in zo'n oefening kunnen ondersteunen?

De kleuren geven weer of wel of niet het continent gespeeld wordt

3.8 Hoe denk jij over de volgende oefeningen met deze feedback? Hoe ziet de feedback er uit, zou het ondersteunend zijn, hoe zie jij die oefening voor je?

- **a. speel hetzelfde ritme als..... de docent, een klasgenoot, de heleklas, de klasgenoot tegenover je**
- **b. speel een kanon of meerstemmig**
- **c. zoek iemand die.... hetzelfde ritme speelt**
- **d. speel allemaal een ander ritme**

a. leuk, zou ik doen. Ja is duidelijk b. ik denk dat dat duidelijk is. eerst in groepen verdelen en de groepen bij elkaar zetten, zelf zou ik in het midden gaan staan zodat je beide groepen kunt begeleiden. c. Is een leuk idee, maar dan moeten ze wel een beetje verstand hebben van ritme, gevoel voor ritme, en musicale vaardigheid. Een hogere klas (boven groep 5) kan het te ingewikkeld maken. Kennis van ritmes wordt steeds groter. Groep 1 a 2 a 3 is vier tellen slaan is het ritme. d. In de bovenbouw is het sowieso leuk, omdat het een creatief proces is

3.9 Hoe zou de feedback verbeterd kunnen worden?

Duidelijk aangeven dat het om basis ritmes gaat en voorbeelden geven, hele tellen, halve tellen etc.

3.10 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Dit werkt in de bovenbouw het best, want die kinderen hebben de meeste kennis van ritmes. Zeker met ‘speel een origineel ritme’, want dat gaat ervoor zorgen dat er zoveel mogenlijk ritmes bedacht worden. Verder is het duidelijk, is heel leuk met kinderen om te doen.

Zelfde situatie met paars, aqua en geel https://youtu.be/C0r1s-9M79I

3.11 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

Even duidelijk

3.12 Hoeveel kleuren zouden we kunnen/moeten gebruiken?

Ik denk dat je bij de hoofdkleuren moet blijven,

3.13 Welke kleuren zijn goed van elkaar te onderscheiden?

Alle kleuren zijn goed van elkaar te onderscheiden

4. <u>foto van verschillende kleurtjes</u>

4.1 Welke zijn goed van elkaar te onderscheiden? (ooghoeken, is dat nodig?)

Alles goed van elkaar te onderscheiden. Is moeilijk om te zeggen of het voor de hele klas ook duidelijk is, want veel leerlingen.

4.2 Waar zou je nog meer de kleurtjes voor kunnen gebruiken?

Hard zacht, hoe feller het lichtje, hoe harder je speelt, een aantal splen zacht en een aantal hard. En focus op dynamiek. Die laatste met al die kleurtjes, 6 kleurtjes voor de 6 vormen van dynamiek.

4.3 Hoe denk je over deze manier van feedback (lichtgevende instrumenten)? Zou het van toegevoegde waarde kunnen zijn?

Zeker van toegevoegde waarde, heel stimulerend, heel leuk om te doen met kinderen, en kan echt een hulpmiddel zijn voor docenten die het lasting vinden om geluid van elkaar te onderscheiden

Hoe zou je het nog meer in kunnen zetten tijdens een muziek les over ritme?

Nog geen extra ideeen.

Nog meer (algemene) opmerkingen?

Geen aanvullende opmerkingen

8b – Interview participant 2

Age: 22

Sex: vrouw

Pabo student year: 3

1. **<u>Saturation:</u>**

De hele groep speelt samen een ritme, maar een slag van het ritme mag maar geslagen worden door alleen de leerling die aan de beurt is. De leerlingen zullen dus goed op moeten letten om op het juiste moment een slag te slaan.

video bekijken https://youtu.be/JUKoB-fjAcQ

1.1 Wat denk jij over deze feedback?

Als het lampje brand mag je slaan

1.2 Welke leerling slaat op het verkeerde ritme?

Het is niet heel duidelijk wanneer een kind fout slaat. Wanneer die knippert wordt er verkeerd geslagen

Het idee is dat zolang het ritme goed gespeeld wordt, de lampjes steeds feller worden. Zodra er een verkeerde slag geslagen is, zal die persoon opnieuw moeten beginnen.

1.3 Wat denk je nu over deze feedback?

Ik snap de gedachte nu beter, maar is lastig toe te passen, want als leerling kan het confronterend zijn. Ik zou eerste oefenen zonder lampjes. Let op de onzekerhied van kinderen

1.4 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Wordt spannend ivm onzekere kindjes, het ligt aan de groep, veilige groep of pest groep. Ik zou het zelf leuk vinden om te gebruiken, maar dan zou ik eerst oefenen zonder lampjes

1.5 Hoe zou de feedback verbeterd kunnen worden?

Op een ipad of computerscherm, dus alleen voor kinderen of leerkracht. Kan ook leuk en vernieuwend zijn

2. Tempo:

Elke leerling speelt een bepaald ritme, tegelijkertijd. Dit kan een ritme zijn wat de docent speelt, van een bestaand nummer etc. Sommige leerlingen spelen te langzaam, anderen te snel.

video bekijken https://youtu.be/BgvubFNG2PU

2.1 Wat denk jij over deze feedback?

Het is heel duidelijk, alleen weet ik niet of de kinderen die het niet goed spelen door dat lampje wel goed kunnen spelen. Ik denk dat dat wel duidelijk is

2.2 Welke leerling slaat op het verkeerde ritme? Welke te snel en welke te langzaam

Als het lampje rood is speel je te snel, en met blauw lampje te langzaam, paars is goede tempo

Het idee is dat groen de 'juiste' kleur is, want dat is een mengsel van geel en blauw. Als er een leerling te lanzaam of te snel gaat veranderd het instrument naar geel of blauw.

2.3 Wat denk je nu over deze feedback?

Is al besproken in 2.1

2.4 Welke kleur (geel of blauw) zou snel moeten zijn en welke langzaam?

Geel is niet het goede tempo, blauw te snel en geel te langzaam. De paarse is duidelijker

2.5 Stel er zouden meer leerlingen zijn die te langzaam of te snel spelen, zou je dan nog steeds overzicht hebben?

Ik zou er zeker wat aan hebben, maar ik zou het achteraf willen terugzien. Achteraf nog een keer oefenen.

2.6 Hoe zou de feedback verbeterd kunnen worden?

Het zou verbeterd kunnen worden als de je de leerlingen terug kunt kijken, liever niet tijdens het ritme spel verbeteren, want dat stoort de concentratie

Zelfde situatie met paars, blauw en rood https://youtu.be/hqBI-HUuJP4

2.7 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

A liever groene lampjes want rood is ‘fout’, groen is vriendelijker. Minder erg om een fout te maken

2.8 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Kinderen vinden het sowiso leuk om een trommel te gebruiken die lichtgeeft

3. Syncing:

Elke leerling speelt een bepaald ritme en sommige kunnen (per ongeluk of expres) hetzelfde ritme spelen.

video bekijken https://youtu.be/RwYheuaxCII

3.1 Wat denk jij over deze feedback?

Heel lastig om te zien wat de kleurtjes doen

3.2 Welke leerlingen spelen hetzelfde ritme?

Die met dezelfde kleur spelen hetzelfde ritme. De witte trommel is gestopt met spelen

Het idee is dat dezelfde kleuren hetzelfde ritme spelen, behalve wit want wit betekent dat je een origineel ritme speelt.

3.3 Wat denk je nu over deze feedback?

Het is sowieso een lastige opdracht. Voor jonge kinderen is het lastig om op hetzelfde moment verschillende ritmes te spelen. Je zou het kunnen gebruiken in de bovenbouw vanaf groep 6. Ik zou iedere partij bij elkaar zetten.

3.4 Welke leerlingen spelen een origineel ritme? Is dit duidelijk?

Het is duidelijk dat de witte een origineel ritme spelen, maar ik zou niet weten wat ik ermee zou moetne

3.5 Kun je goed de verschillende kleuren onderscheiden

Op de video is het kleurverschil niet zo duidelijk, RGb is duidelijker

3.6 Welke oefeningen zou je kunnen doen mbv deze feedback?

Kanon, twee verschillende ritmes. Twee verschillende partijen laten spelen.

Maar ik zou ze wat minder door elkaar laten spelen en omstebeurt een ritme laten horen.

3.7 Hoe zou de feedback de docent in zo'n oefening kunnen ondersteunen?

Ik zou bij het goede ritme het lampje laten branden en in nog net niet goed ritme niet, ik denk dat dat minder motiverend is dan een 'fout' lampje. Als je geoefend hebt en je hebt het gebruikt is het niet meer verwarrend omdat je dan weet hoe het werkt. Je zou ook dovende lampjes kunnen gebruiken die aan gaan als het goed gaat.

3.8 Hoe denk jij over de volgende oefeningen met deze feedback? Hoe ziet de feedback er uit, zou het ondersteunend zijn, hoe zie jij die oefening voor je?

a. speel hetzelfde ritme als..... de docent, een klasgenoot, de heleklas, de klasgenoot tegenover je
b. speel een kanon of meerstemmig
c. zoek iemand die.... hetzelfde ritme speelt
d. speel allemaal een ander ritme

a. is leuk, maar ik zou degene die het voorspeelt eerst laten spelen voordat de rest speelt. Want het is lastig om het goede ritme te horen als veel kinderen spelen
b. de ene partij is bijvoorbeeld blauw en die gaan bij elkaar zitten zodat ze elkaar kunnen horen. Geel speelt het ene ritme en blauw speel thet andere ritme.
   In het begin zal het heel rommelig zijn als kinderen niet weten wat het lampje is. Grote chaos
c. zou ik alleen met een gevorderde groep doen, want om een ritme te spelen en te blijven spelen is lastig en zeker als je het ritme moet lezen en iedereen een ander ritme speelt, maar als je een klas hebt die dat aan kan is dat leuk.
d. Ook leuk maar ook moeilijk.

3.9 Hoe zou de feedback verbeterd kunnen worden?

Door minder door elkaar te laten spelen en het achteraf terug te kunnen zien

3.10 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Is heel chaotisch, dus alleen met een gevorderde groep en ik kleine stapjes aanbieden. Bijv. Eerst de blauwe dan de rode oefenen en de feedback pas aanzetten nadat er geoefend is. Geen paars gebruiken of niet vertellen wat het betekend, of achteraf feedback zonder dat de lampjes aan staan

Zelfde situatie met paars, aqua en geel https://youtu.be/C0r1s-9M79I

3.11 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

RGb is duidelijker

3.12 Hoeveel kleuren zouden we kunnen/moeten gebruiken?

Ligt aan de opdracht, zoek een maatje is leuk als je een andere kleur hebt. Veel verschillende ritmes wordt verwarrend

3.13 Welke kleuren zijn goed van elkaar te onderscheiden?

RGB wel andere minder

4. <u>foto van verschillende kleurtjes</u>

4.1 Welke zijn goed van elkaar te onderscheiden? (ooghoeken, is dat nodig?)

Alle groenige lijken op elkaar, verder zijn ze goed te zien, paars en licht paars zijn niet heel duidelijk. Met veel leerlingen zo min mogelijk kleuren of je lampje uit, vooral niet te veel kleuren. Een lampje wat uit is geeft meer motivatie dan een andere kleur lampje denk ik

4.2 Waar zou je nog meer de kleurtjes voor kunnen gebruiken?

Geen idee

4.3 Hoe denk je over deze manier van feedback (lichtgevende instrumenten)? Zou het van toegevoegde waarde kunnen zijn?

Demotiverend en rommelig. Ik zou het wel willen gebruiken maar dan wel rustig opbouwen. Ja is leuk, maar stapje voor stapje, is leuke aanvulling en vernieuwing en kan motiveren

Hoe zou je het nog meer in kunnen zetten tijdens een muziek les over ritme?

Misschien ook met zingen, of zingen en trommelen, lampje branden als je goede ritme speelt, bandje met andere instrumenten.

Nog meer (algemene) opmerkingen?

Ik vind het een leuk onderzoek, maar lastig om in te schatten. Eigenlijk moet je dat in het echt willen proberen.

8c – Interview participant 3

Age: 22

Sex: vrouw

Pabo student year: 3

1. **<u>Saturation:</u>**

De hele groep speelt samen een ritme, maar een slag van het ritme mag maar geslagen worden door alleen de leerling die aan de beurt is. De leerlingen zullen dus goed op moeten letten om op het juiste moment een slag te slaan.

video bekijken https://youtu.be/JUKoB-fjAcQ

1.1 Wat denk jij over deze feedback?

Lichtjes zijn handig voor docent. Als je weet hoe het werkt.

1.2 Welke leerling slaat op het verkeerde ritme?

De groene want de lampjes gaan eerst netjes in een rondje en dan gaat het lampje knipperen. Ze gaan ook steeds harder en zachter

Het idee is dat zolang het ritme goed gespeeld wordt, de lampjes steeds feller worden. Zodra er een verkeerde slag geslagen is, zal die persoon opnieuw moeten beginnen.

1.3 Wat denk je nu over deze feedback?

Feedback is motiverent want dan weet je ow we moeten nu nog beter opletten. Is vooral handig als de leerlingen al wat verder zijn in het gebruik van de instrumenten vooral als je voor het eerste een trommel gebruikt en nog niet zo goed bent in een ritme slaan, want als dat niet zo is dat kom je niet heel veel verder. Kan erg motiveren om het goed te doen

1.4 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Ze vinden het interesant en een nieuwe manier. Het motiveert ze wel, want is net wat extra’s

1.5 Hoe zou de feedback verbeterd kunnen worden?

Ik kan zo niks bedenken

2. Tempo:

Elke leerling speelt een bepaald ritme, tegelijkertijd. Dit kan een ritme zijn wat de docent speelt, van een bestaand nummer etc. Sommige leerlingen spelen te langzaam, anderen te snel.

video bekijken https://youtu.be/BgvubFNG2PU

2.1 Wat denk jij over deze feedback?

De kleur veranderd als de leerling te snel of te langzaam is

2.2 Welke leerling slaat op het verkeerde ritme? Welke te snel en welke te langzaam

Kan niet zien welke te snel of te langzaam is. Groen lampje is goed.

Het idee is dat groen de 'juiste' kleur is, want dat is een mengsel van geel en blauw. Als er een leerling te lanzaam of te snel gaat veranderd het instrument naar geel of blauw.

2.3 Wat denk je nu over deze feedback?

Is besproken in 2.1

2.4 Welke kleur (geel of blauw) zou snel moeten zijn en welke langzaam?

Blauw is te snel en geel is te langzaam. Blauw te snel en rood te langzaam.

2.5 Stel er zouden meer leerlingen zijn die te langzaam of te snel spelen, zou je dan nog steeds overzicht hebben?

De kinderen zien al feedback bij zichzelf, dus ze kunnen het zelf al aanpassen en daarbij komt de leraar er ook nog eens bij, zeker bij de kinderen die al wat ouder zijn. Dus het is opzich goed te doen

2.6 Hoe zou de feedback verbeterd kunnen worden?

Ik vind dit erg duidelijk

Zelfde situatie met paars, blauw en rood https://youtu.be/hqBI-HUuJP4

2.7 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

Voorkeur voor groen want voorkeur voor goed. Groen is goed.

2.8 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Het is nieuw en ze kennen het nog niet, dus is fijn dat ze weten dat ze het goed doen en motivatie hebben om het lampje groen te houden.

3. <u>Syncing:</u>

Elke leerling speelt een bepaald ritme en sommige kunnen (per ongeluk of expres) hetzelfde ritme spelen.

video bekijken https://youtu.be/RwYheuaxCII

3.1 Wat denk jij over deze feedback?

Als het wit is moeten ze stoppen met spelen en de kleuren wisselen, elk kind speelt elke keer een ander ritme

3.2 Welke leerlingen spelen hetzelfde ritme?

Met die kleurtjes is dat duidelijk te zien --> geel paars en blauw spelen het gele ritme

Het idee is dat dezelfde kleuren hetzelfde ritme spelen, behalve wit want wit betekent dat je een origineel ritme speelt.

3.3 Wat denk je nu over deze feedback?

Is ingewikkeld

3.4 Welke leerlingen spelen een origineel ritme? Is dit duidelijk?

De witte speelt niet meer, is wel even wennen dat wit een originele kleur is, lijkt dat die hetzelfde ritme speelt als het andere ritme.

3.5 Kun je goed de verschillende kleuren onderscheiden

In de filmpjes duidelijk, maar met heel veel kleuren moet je even goed kijken

3.6 Welke oefeningen zou je kunnen doen mbv deze feedback?

Ritme memory

3.7 Hoe zou de feedback de docent in zo'n oefening kunnen ondersteunen?

Zelfde kleur is zelfde memory

3.8 Hoe denk jij over de volgende oefeningen met deze feedback? Hoe zie de feedback er uit, zou het ondersteunend zijn, hoe zie jij die oefening voor je?

a. speel hetzelfde ritme als..... de docent, een klasgenoot, de heleklas, de klasgenoot tegenover je
b. speel een kanon of meerstemmig
c. zoek iemand die.... hetzelfde ritme speelt
d. speel allemaal een ander ritme

a. heel goed organiseren want anders wordt het chaos, wat grotere groepjes zodat er minder onrust is. Ik zou beginnen met minder verschillende ritmes of in tweetallen mits ze dat zelfstandig kunnen.
b. Dat kan goed helpen omdat het moeilijk is om te blijven zingen wat je moet zingen, dus het geeft een soort hou vast als je instrument dezelfde kelur is. Bevestiging is fijn. Dus in groepen bij elkaar om goed overzicht te houden
c. Dat is een hele leuke en ik denk dat kinderen dat ook echt goed kunnen, want cooperatieve werkvormen worden meer toegepast dus zou leuk zijn als dat in deze vorm in muziek toe te voegen is. Ze moeten het wel zelfstandig kunnen.
d. Wel grappig, ander ritme spelen. Bevestiging van die kleurtjes.

3.9 Hoe zou de feedback verbeterd kunnen worden?

Let op met het verschil aan kleuren, moet goed te herkennen zijn

3.10 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Dit zal meer verwarrend zijn dan de vorige twee opdrachten omdat er zoveel verschillende kleuren zijn. Maar kleurtjes zijn leuk dus dat vinden kinderen wel leuk, maar het zou wel wat sneller ingewikkeld kunnen worden dus zouden kinderen sneller kunnen afhaken.

Zelfde situatie met paars, aqua en geel https://youtu.be/C0r1s-9M79I

3.11 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

Aqua lijkt op de blauwe, maakt verder niet uit welke van de twee, want los van elkaar is het verschil goed te zien

3.12 Hoeveel kleuren zouden we kunnen/moeten gebruiken?

15 verschillende kleuren, want dan kan je duo's maken in een klas van 30 leerlingen. Kleurverschil is wel moeilijk te zien dan

3.13 Welke kleuren zijn goed van elkaar te onderscheiden?

Besproken in 4.1

4. <u>foto van verschillende kleurtjes</u>

4.1 Welke zijn goed van elkaar te onderscheiden? (ooghoeken, is dat nodig?)

Twee soorten paars achtige die lijken op elkaar. Je ziet het verschil, maar minder duidelijk contrast. De lichtblauwe lijkt heel erg op de turquase.

4.2 Waar zou je nog meer de kleurtjes voor kunnen gebruiken?

Is moeilijk te verzinnen

4.3 Hoe denk je over deze manier van feedback (lichtgevende instrumenten)? Zou het van toegevoegde waarde kunnen zijn?

Ik denk dat het van toegevoegde waarde kan zijn, omdat je het niet altijd goed kunt horen wat er waar fout gaat, dus als een instrument verkleurd weet je dat je het daar aan moet pakken. Dus zorgt voor overzicht.

Hoe zou je het nog meer in kunnen zetten tijdens een muziek les over ritme?

Met visualisatie van wat voor ritme je kan spelen. Ritmes doorgeven.

Nog meer (algemene) opmerkingen?

Is echt heel interresant en ik denk dat het echt goed kan werken vooral vanaf middenbouw (na de kleuters). **Hoe zou een kind reageren wat niet zo goed is?** Frustrerend als een kind het niet kan, eerst langzamer spelen, de oefening makkelijekre maken. Kleurverschil is duidelijk

8d – Interview participant 4

Age: 21

Sex: vrouw

Pabo student year: 3

1. **<u>Saturation:</u>**

De hele groep speelt samen een ritme, maar een slag van het ritme mag maar geslagen worden door alleen de leerling die aan de beurt is. De leerlingen zullen dus goed op moeten letten om op het juiste moment een slag te slaan.

video bekijken https://youtu.be/JUKoB-fjAcQ

1.1 Wat denk jij over deze feedback?

Ze spelen hard en zacht, en er is iets met de kleur om het ringetje. Er zijn 10 rondjes, maar 2 keer dezelfde kleur.

1.2 Welke leerling slaat op het verkeerde ritme?

Is zonder uitleg niet duidelijk. Na het te weten is het wel duidelijk

Het idee is dat zolang het ritme goed gespeeld wordt, de lampjes steeds feller worden. Zodra er een verkeerde slag geslagen is, zal die persoon opnieuw moeten beginnen.

1.3 Wat denk je nu over deze feedback?

Ik denk dat het wel handig is, iets op de goede manier of hard genoeg of zacht genoeg. Omdat je zelf niet de capaciteit hebt om dat te horen, maar er is wel uitleg nodig.

1.4 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Er zal groepsdruk zijn, want het kan wel demotiverend zijn als het steeds hetzelfde kind zou zijn. Gelukkig is er geen afkeurend geluid

Hoe zou je ermee om kunnen gaan dat het frustrerend wordt?

Starten bij een ander kind, ander instrument

1.5 Hoe zou de feedback verbeterd kunnen worden?

Goede uitleg, en het toepassen van een voorbeeld rondje

2. **<u>Tempo:</u>**

Elke leerling speelt een bepaald ritme, tegelijkertijd. Dit kan een ritme zijn wat de docent speelt, van een bestaand nummer etc. Sommige leerlingen spelen te langzaam, anderen te snel.

video bekijken https://youtu.be/BgvubFNG2PU

2.1 Wat denk jij over deze feedback?

Duidelijk, de lichtjes gaan aan en dan moet je hard spelen en andere ritmes komen erbij

2.2 Welke leerling slaat op het verkeerde ritme? Welke te snel en welke te langzaam

Licht wordt wat minder, die leerlingen doen het fout. Eerst wordt het paars en hij wordt rood als het verkeerd gaat. Is blauw goed? En rood slecht?

Het idee is dat groen de 'juiste' kleur is, want dat is een mengsel van geel en blauw. Als er een leerling te lanzaam of te snel gaat veranderd het instrument naar geel of blauw.

2.3 Wat denk je nu over deze feedback?

Duidelijk, ik denk dat per groep precies wordt aangegeven waar je te snel of te langzaam gaat voor de kinderen, dus kinderen weten hoe ze er op in moeten gaan

2.4 Welke kleur (geel of blauw) zou snel moeten zijn en welke langzaam?

Rood gaat te snel en blauw te langzaam. Blauw snel en geel langzamer. Niet echt een voorkeur. Rood kan afschrikken. Rood en blauw is duidelijker omdat de kleuren tegenovergesteld zijn.

2.5 Stel er zouden meer leerlingen zijn die te langzaam of te snel spelen, zou je dan nog steeds overzicht hebben?

Met 30 zou dat niet zo heel handig zijn omdat dat te onoverzichtelijk is en je het niet goed zou kunnen zien. Je zou met minder instrumenten kunnen werken. Ik werk graag met kleine groepjes.

2.6 Hoe zou de feedback verbeterd kunnen worden?

Duidelijk aangeven wat rood en blauw betekend.

Zelfde situatie met paars, blauw en rood https://youtu.be/hqBI-HUuJP4

2.7 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

Paarse is duidelijker dan de groene, vooral de overgang gaat niet zo goed in de groene

2.8 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Wel goed, er valt duidelijk te zien wat ze moeten doen

3. <u>Syncing:</u>

Elke leerling speelt een bepaald ritme en sommige kunnen (per ongeluk of expres) hetzelfde ritme spelen.

video bekijken https://youtu.be/RwYheuaxCII

3.1 Wat denk jij over deze feedback?

Verschillende kleuren, de AYP is duidelijker. Je kan gelijk zien welke kinderen hetzelfde spelen.

3.2 Welke leerlingen spelen hetzelfde ritme?

De witte spelen niet

Het idee is dat dezelfde kleuren hetzelfde ritme spelen, behalve wit want wit betekent dat je een origineel ritme speelt.

3.3 Wat denk je nu over deze feedback?

Is besproken in 3.1

3.4 Welke leerlingen spelen een origineel ritme? Is dit duidelijk?

Met uitleg is het duidelijk

3.5 Kun je goed de verschillende kleuren onderscheiden

Kleuren zijn moeilijk te onderscheiden

3.6 Welke oefeningen zou je kunnen doen mbv deze feedback?

Begin met hetzelfde en laat om de beurt een kind een ander ritme spelen. Je zou ook een spel kunnen spelen dat ze het niet van elkaar kunnen horen en toch dezelfde kleur moeten proberen te spelen

3.7 Hoe zou de feedback de docent in zo'n oefening kunnen ondersteunen?

Door het instrument kan je zien of echt ieder kind een ander ritme speelt

3.8 Hoe denk jij over de volgende oefeningen met deze feedback? Hoe zie de feedback er uit, zou het ondersteunend zijn, hoe zie jij die oefening voor je?

a. speel hetzelfde ritme als..... de docent, een klasgenoot, de heleklas, de klasgenoot tegenover je
b. speel een kanon of meerstemmig
c. zoek iemand die.... hetzelfde ritme speelt
d. speel allemaal een ander ritme

a. iedereen een instrument en het zelf eerst voordoen. Goed uitleggen wat voor ritme er gespeeld moet worden en dan nadoen
b. kanon van drie in drie groepjes verdelen of eerst met het hele groepje het hele stuk oefenen
c. is leuk, cooperatieve werkvorm. De klas in tweeen verdelen en ieder kind een ander ritme geven en zoek elkaar van 1 ritme twee kaartjes. Misschien eerst de een zijn ritme laten spelen en dan de ander.
d. Is niet handig om dat in te zetten. Wel een leuke nieuwe manier van kijken naar de instrumenten. Wel zou je kunnen beginnen met hetzelfde en laat om de beurt een kind een ander ritme spelen, misschien ook zonder dat ze het van elkaar kunnen horen

3.9 Hoe zou de feedback verbeterd kunnen worden?

Ik heb zo snel niet echt iets, qua kleuren was het duidelijk. Uitleg is ook duidelijk.

3.10 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Daar zouden ze wel goed op reageren, als leerkracht kan je het goed inzetten

Zelfde situatie met paars, aqua en geel https://youtu.be/C0r1s-9M79I

3.11 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

3.12 Hoeveel kleuren zouden we kunnen/moeten gebruiken?

Niet teveel kleuren die teveel op elkaar lijken. 6 of 7 is lastig.

3.13 Welke kleuren zijn goed van elkaar te onderscheiden?

Alles behalve de blauwtinten

4. <u>foto van verschillende kleurtjes</u>

4.1 Welke zijn goed van elkaar te onderscheiden? (ooghoeken, is dat nodig?)

Blauw, oranje en rood, die drie lijken op elkaar, de blauwachtige tinten. En lichtpaars en donker paars zijn wel goed van elkaar te onderscheiden. Wit blauw rood is heel goed van elkaar te onderscheiden. Dus paars blauw rood groen en of oranje of geel

4.2 Waar zou je nog meer de kleurtjes voor kunnen gebruiken?

Iets met flikkeren, als er iets mis gaat, snel flikkeren of langzaam flikkeren, te hard of te zacht.

4.3 Hoe denk je over deze manier van feedback (lichtgevende instrumenten)? Zou het van toegevoegde waarde kunnen zijn?

Wel handig, en het kan heel makkelijk. Ten minste, het lijkt niet een heel bijzonder apparaat.

Hoe zou je het nog meer in kunnen zetten tijdens een muziek les over ritme?

Kan zo snel even niets bedenken

Nog meer (algemene) opmerkingen?

Niet echt. Met de kleurtjes, cijfer.

8e – Interview participant 5

Age: 21

Sex: vrouw

Pabo student year: 3

1. **Saturation:**

De hele groep speelt samen een ritme, maar een slag van het ritme mag maar geslagen worden door alleen de leerling die aan de beurt is. De leerlingen zullen dus goed op moeten letten om op het juiste moment een slag te slaan.

video bekijken https://youtu.be/JUKoB-fjAcQ

1.1 Wat denk jij over deze feedback?

Het lampje wat brand, die is aan slag.

1.2 Welke leerling slaat op het verkeerde ritme?

Als het lampje heel fel is is het goed en anders moet je je ritme bijschaven

Het idee is dat zolang het ritme goed gespeeld wordt, de lampjes steeds feller worden. Zodra er een verkeerde slag geslagen is, zal die persoon opnieuw moeten beginnen.

1.3 Wat denk je nu over deze feedback?

Is leuk dat de lampjes steeds feller worden, leerlingen worden daar wat gedrevener door. Maar ik weet niet of het goed is of om alle lampjes uit te laten gaan ivm demotivatie

1.4 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Niet heel handig om ze uit te laten gaan, want dat kan demotiverend zijn. Maar wel goede oefening. de lampjes zijn duidelijk want dan weet je waar je aan kunt oefenen.

1.5 Hoe zou de feedback verbeterd kunnen worden?

Niet uit laten gaan maar op hetzelfde niveau laten branden. Een belonings element met bijv. groen einddoel toevoegen

2. **Tempo:**

Elke leerling speelt een bepaald ritme, tegelijkertijd. Dit kan een ritme zijn wat de docent speelt, van een bestaand nummer etc. Sommige leerlingen spelen te langzaam, anderen te snel.

video bekijken https://youtu.be/BgvubFNG2PU

2.1 Wat denk jij over deze feedback?

Als iedereen het goed doet worden de lampjes paars

2.2 Welke leerling slaat op het verkeerde ritme? Welke te snel en welke te langzaam

Blauw is te langzaam en rood te snel. Blauw langzaam en geel snel. Mijn voorkeur gaat uit naar paars want rood en blauw liggen dicht bij paars dus dat vloeit beter in.

Het idee is dat groen de 'juiste' kleur is, want dat is een mengsel van geel en blauw. Als er een leerling te lanzaam of te snel gaat veranderd het instrument naar geel of blauw.

2.3 Wat denk je nu over deze feedback?

Kan helpen om uit te vinden welke kinderen te snel of te langzaam speelt

2.4 Welke kleur (geel of blauw) zou snel moeten zijn en welke langzaam?

Is besproken in 2.2

2.5 Stel er zouden meer leerlingen zijn die te langzaam of te snel spelen, zou je dan nog steeds overzicht hebben?

In dat geval klassikaal stillleggen, en opnieuw beginnen. Dus feedback is nog steeds nuttig. Als je als leerkracht geen gevoel voor ritme heeft kan dit heel erg helpen om te zien of een leerling wel of niet te snel of te lanzaam gaat

2.6 Hoe zou de feedback verbeterd kunnen worden?

Is duidelijk en logisch, en je ziet het verschil in kleur dus rood of blauw, hoe dichter bij het ritme hoe beter het werd

Zelfde situatie met paars, blauw en rood https://youtu.be/hqBI-HUuJP4

2.7 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

Is besproken in 2.2

2.8 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Ik hoop dat ze niet te veel op elkaar gaan letten

3. <u>Syncing:</u>

Elke leerling speelt een bepaald ritme en sommige kunnen (per ongeluk of expres) hetzelfde ritme spelen.

video bekijken https://youtu.be/RwYheuaxCII

3.1 Wat denk jij over deze feedback?

Spelen als het lampje aan is en stoppen als het lampje uit is

3.2 Welke leerlingen spelen hetzelfde ritme?

De drie middelste leerlingen lichten op.

Het idee is dat dezelfde kleuren hetzelfde ritme spelen, behalve wit want wit betekent dat je een origineel ritme speelt.

3.3 Wat denk je nu over deze feedback?

dat is duidelijk te zien

3.4 Welke leerlingen spelen een origineel ritme? Is dit duidelijk?

Wit betekend of dat de leerlingen het goed spelen, of de leerlingen met een witte trommel hebben rust. Je zou dingen in groepjes kunnen doen, zodat je weet waar je moeten luisteren. Dan kunnen ze het zelf ook in de gaten houden.

3.5 Kun je goed de verschillende kleuren onderscheiden

Is besproken in 4.1

3.6 Welke oefeningen zou je kunnen doen mbv deze feedback?

Ritmische begeleiding oefeneningen. Vraag antwoord --> een groep speelt het eerst andere speelt een andere, ene speelt het eerst andere speelt het na. Verschillende groepjes verschillende ritmes

3.7 Hoe zou de feedback de docent in zo'n oefening kunnen ondersteunen?

Je weet wie in welk groepje zit, dus de kleur van een leerling is mis als ze niet met de rest overeen komen

3.8 Hoe denk jij over de volgende oefeningen met deze feedback? Hoe zie de feedback er uit, zou het ondersteunend zijn, hoe zie jij die oefening voor je?

a. **speel hetzelfde ritme als..... de docent, een klasgenoot, de heleklas, de klasgenoot tegenover je**
b. **speel een kanon of meerstemmig**
c. **zoek iemand die.... hetzelfde ritme speelt**

d. speel allemaal een ander ritme

a. is een goeie, is een soort leuke warming up oefening. Ook voor individuele leerlingen met 1tje die het voorspeelt
b. verschillende partijen tegelijk, dus goed idee
c. is een leuke, mix en matcht met andere vakken, dus leerlingen weten al hoe dat werkt
d. zou ik iets minder snel doen, want chaos. Wat minder gericht op ritme. Meer individueel dan met een groep. Maar wel leuk als je varieert in het basisritme.

3.9 Hoe zou de feedback verbeterd kunnen worden?

3.10 Hoe zou dit werken met een groep basisschoolkinderen die het instrument bespelen?

Ik denk dat ze het echt leuk zouden vinden zeker de zoek opdrachten. Meer aantrekkelijker voor de onderbouw dan voor de bovenbouw. Bovenbouw mag wat moeilijker. Dus moeilijkheid moet je aanpassen aan de groep. Onderbouw is meer naklappen, bovenbouw is meer creatief

Zelfde situatie met paars, aqua en geel https://youtu.be/C0r1s-9M79I

3.11 Is dit beter, slechter, anders, wat zijn jouw bevindingen of interpretaties?

Rood geel en blauw; aqua en paars kan op elkaar lijken.

3.12 Hoeveel kleuren zouden we kunnen/moeten gebruiken?

15 kleuren voor duo's. Je zou de rand van de trommel kunnen gebruiken om nog meer in kleur te varieren

3.13 Welke kleuren zijn goed van elkaar te onderscheiden?

De kleuren met het meeste contrast

4. <u>foto van verschillende kleurtjes</u>

4.1 Welke zijn goed van elkaar te onderscheiden? (ooghoeken, is dat nodig?)

Rood, donkerblauw, gele geeft het meeste contrast. De paarse en de groene lijken op elkaar.

4.2 Waar zou je nog meer de kleurtjes voor kunnen gebruiken?

Speel het ritme wat door de lichtjes geknippert wordt, bodysounds gebruiken

4.3 Hoe denk je over deze manier van feedback (lichtgevende instrumenten)? Zou het van toegevoegde waarde kunnen zijn?

Is cool, technologie is sowieso cool. Kan je zeker toepassen om de puntjes op de i te zetten en om ze dingen aan te leren. Geef elkaar feedback en zonder feedback.

Hoe zou je het nog meer in kunnen zetten tijdens een muziek les over ritme?

nee

Nog meer (algemene) opmerkingen?

Nee, ik vind het interresant, en ik ben wel benieuwd naar de hele uitkomst.