UNIVERSITY OF GOTHENBURG
FACULTY OF EDUCATION

What is possible to learn?

A study of the learners' perspectives of a novel technology, MIROR Body Gesture

Sarah Mercieca

Thesis:	30 credits
Program and/or course:	International Masters of Educational Research
Department:	Education and Special Education
Level:	Second cycle (advanced)
Term/year:	Spring 2014
Supervisor:	Dr Cecilia Wallerstedt
Examiner:	Prof Dennis Beach
Rapport nr:	xx (a number will be given by the administrator while handing in)

Abstract

Thesis:	30 credits
Program and/or course:	International Masters of Educational Research
Level:	Second cycle
Term/year:	Spring 2014
Supervisor:	Dr Cecilia Wallerstedt
Examiner:	Prof Dennis Beach
Rapport nr:	xx (a number will be given by the administrator while handing in)
Keywords:	learners' perspectives, variation theory, music technology, object of learning

---

Aim: Previous research within the Musical Interaction Relying On Reflection (MIROR) project has underestimated children's own voices when investigating learning enhancing music technology. This study uncovers six young children's perspectives regarding what is possible to learn when interacting with a novel music technology known as MIROR Body Gesture (BG).

Theory: The theoretical framework of Variation theory is adopted to explore the intended, enacted and lived object of learning.

Method: Document analysis, video observations and interviews shed light on what the children in this study are enabled to learn when using this specific music technology. This analysis exposes a distinct discrepancy between the different objects of learning.

Results: The children expressed that this technology provided them with the possibilities to; experience contrast between different sounds, become aware of the technology's function to generate these differences or variations in the sounds and of their own movements' function to initiate these variations. These lived experiences are distinct from the intended object of learning which aimed at increasing children's awareness of the different sound morphology including pitch, lateralization, distortion, density and dynamic accent. The learners' perspectives also provided insight that verified and refuted the researcher's perspectives concerning the learning situation. This insight gives a clearer overview of what is possible to discern through using BG and presents implications for its further improvements.

Acknowledgements

I gratefully acknowledge the University of Gothenburg research team (UGOT), consisting of a collaboration between the Academy of Music and Drama and the Department of Education, and its members who have given me this opportunity to participate in their research project. I would like to thank Professor Bengt Olsson, Professor Ingrid Pramling Samuelsson, Professor Niklas Pramling, Dr Cecilia Wallerstedt, Dr Åsa Bergman and Ms Pernilla Lagerlöf who have welcomed me in their team and inspired this study.

I would like to express the deepest appreciation to my tutor Dr Cecilia Wallerstedt who has offered her guidance and persistent help throughout this journey. Without her support and advice this thesis would not have been possible. I would also like to acknowledge the assistance rendered by Professor Shirley Booth who dedicated her time to discuss and offer her precious advice. I consider myself lucky that I have had such an inspiring lecturer as Professor Booth, who motivated this thesis theoretical framework. Alongside Professor Åke Ingerman, Professor Booth introduced me to Variation theory which has shaped my research interests and curiosities.

In addition, I would like to thank Ms Elizabeth Olsson, Ms Sue Lewis and Ms Paola Bolivar who have seen this thesis through its birth, development and maturity. Their advice, support and constructive criticism have shaped this thesis to what it is today. Finally, I would like to extend my deepest appreciation to my parents in Malta, who have supported all my ventures and motivated me to always keep striving. I would like to also offer my thanks to Ms Deborah Costa who in times of great insecurity has always given her words of encouragement. Last but not least, I would like to show my gratitude to Mr Mark Piscopo who always made me aware of the light at the end of the tunnel when my vision got blurry. I dedicate this thesis to my nephew, Jacob, in the hopes that one day he'll read it and become inspired to ask questions.

Contents

Abbreviations

MIROR	Musical Interaction Relying On Reflexion
MIROR Impro	MIROR Improvisation
UNCRC	United Nations Convention on the Rights of Children
BG	Body Gesture
RI	Reflexive Interaction
IRMS	Interactive Reflexive Musical Systems
UGOT	University of Gothenburg

List of Tables

List of Figures

Chapter One: Introduction

> Children are and must be seen as active in the construction of their own lives, the lives of those around them and of the societies in which they live in. (James & Prout, p. 8, 1997)

Research concerning new music technology within a project known as MIROR (Appendix 1) has hitherto departed greatly from this conceptualization of childhood (James & Prout, 1997). This thesis aims to bring the study back to such a conceptualization by employing Variation Theory to study the ways in which children experience the music technology MIROR Body Gesture by interacting directly with the children. The research round the MIROR project involved the evaluation of technology for early childhood education with a focus on music learning (MIROR_D2.2.1). The technologies examined included three different software platforms, each tackling different musical skills such as improvisation (MIROR Impro), composition (MIROR Compo) and body performance (MIROR Body Gesture) (MIROR_D2.2.1). All these platforms were designed as Interactive Reflexive Musical Systems (IRMS) around the principle of Reflexive Interaction (RI), each of which makes use of the interaction created between the technology and the users as a learning instrument. The experimental protocol taken up in this research project consisted of systematic observation of children's behaviour while they interacted with these technologies (Addessi & Pachet, 2003; Addessi & Pachet, 2005; Addessi, Ferrari, Carlotti & Pachet, 2006; Benghi, Addessi & Pachet, 2008; Young, 2006). Even though this approach has proven to be efficient in providing information about the technology, it neglects the children's thoughts about a matter that will possibly affect their future music education. Therefore, it fails to provide children with "a critical and democratic…say" (Burnard, 2007, p. 48) on the development of technology designed to enhance their own learning. This becomes problematic because it goes against children's rights of being consulted in matters affecting their lives (UNCRC, 1989, Article 12; Hill, 2006; Chitakunye, 2012).

The ontology underlying this previous research is based on the notion that the study of children's behaviour will lead to the discovery of children's intentions (MIROR_D2.2.1). In contrast, Variation Theory proposes that observing behaviour will only uncover the researcher's perspectives of the learning situation (Marton & Tsui, 2004). Without demeaning any perspectives, Marton and Tsui (ibid.) propose a method of unveiling both the researchers' and the learners' experiences. By recognizing the significance of the children's participation, Variation Theory contributes to a deeper understanding of the outcomes of these music technologies whilst reinforcing the conceptualization of childhood presented by James and Prout (1997).

As a member of the University of Gothenburg team (UGOT) within the MIROR project, I was responsible for evaluating MIROR Body gesture (BG). The Body Gesture platform puts the child in an environment where changes of pitch, loudness and quality of a sound can be changed in accordance with the child's movements. This technology will be described in greater detail in the literature review. As a result of my involvement in this project and my interest in Variation Theory, I became motivated to address the aforesaid blind spot in the project's previous research by examining this technology through a new lens. Even though this thesis is written within the frame of the project and UGOT's obligation as a contributing research partner, I chose to add an explorative stance to the required evaluative research study. Furthermore, even though previous research has been conducted on two IRMSes, this

thesis is one of the first studies to examine BG since it is the latest technology developed within the project. Different to MIROR Impro and Compo it deals with the musical skill of body performance where children can manipulate different sounds through moving their bodies. Together with children as active collaborators, I propose to investigate the learning possibilities enabled or hindered by this technology, facilitated by the use of Variation Theory. Additionally, this insight will also serve as a contribution to the field of technology-based learning, shedding light on the learning potential or limitations of this new technology, specifically with regards to music learning. This research interest has emerged as a result of my growing admiration for research aiming at understanding children's own experiences of childhood, conducted by researchers who are appreciating children as contributing social actors (Mayall, 2001). Therefore, I intend to assess this technology's proposed aims of enhancing children's music learning (MIROR_D4.3.2) by shedding light on learners' perspectives of the learning opportunities provided by the technology.

Thesis Outline

This first chapter involves a description of the aims and research questions addressed in this study. In the second chapter I will present and discuss literature related to research with children, technology based learning, and previous research concerning music technologies specifically within the MIROR project. This will be followed by an account of the theoretical framework of Variation Theory taken up in this study. Chapter three will include a presentation of the methodology, where I will highlight the methods used, their ethical considerations and the methods of analysis. The results will be presented in three different sections in chapter four followed by a discussion in chapter five and conclusion in chapter six, where the findings and their implications will be clarified along with suggestions for further research.

Aim of Study

The aim of this study is to highlight what is possible for children to learn when interacting with BG through illuminating the content of learning from the designers', researcher's and children's perspectives of this interaction. In this study I propose to use Variation Theory (Marton & Tsui, 2004) as my theoretical approach and analytical tool since it lends itself well to illuminating the learners' perspectives. Since this theory is grounded in empirical phenomenographic research, it shares the same non-dualistic ontology that identifies the world as "an internal relation between" (Marton & Booth, 1997, p.15) the person and the world. This 'internal relation' can be explored through adopting a second order perspective where the focus in research concerns people's different experiences. From this approach one cannot understand learning as a separate entity from the learner. Therefore, by employing a second order perspective, I will direct my research focus towards the learners' distinct ways of experiencing the common phenomenon of BG (Marton & Booth, 1997).

Another premise important to Variation Theory is the content of learning, as we cannot talk about learning without first clarifying "'what' we are learning" (Lo, 2012, p.15). I propose to shed light on the intended and the enacted object of learning (Marton & Tsui, 2004), which respectively represent the designers' perspectives of what is expected to be learnt and the researcher's perspectives of what is possible to learn when observing children interact with BG. Nonetheless, the most crucial perspective pertains to the learners, as through taking on a

second order perspective the learners' perspectives will shed light on the lived object of learning representing their own experiences of what is possible to learn in this specific learning situation. These results will enable a greater understanding of this new technology contributing to the body of research within the field of technology-based learning. The methods employed to illuminate these different perspectives include primary document analysis, observations of the interaction between children and technology and semi-structured recall interviews with the participating children. Furthermore, Variation Theory will not only privilege the learner's perspectives, but also shed light on any inconsistencies present between the different objects of learning which can be detrimental to the learning process (Marton & Tsui, 2004; Lo, 2012).

When the learners' perspectives are highlighted the participating children have an opportunity to show their active participation (Burnard, 2007; Laurillard, Oliver, Wasson & Hoppe, 2009) and also have the unique "opportunities to create (and influence) their own learning technologies" (Burnard, 2007, p. 48). Their participation will also benefit the development of this technology (Burnard, 2007; Laurillard, et al., 2009), as the user feedback will assist the technology's developers to improve the prototype in order to provide positive learning opportunities (Laurillard, et al., 2009). It will also shed light on the possibilities and constraints of both Variation Theory and the theoretical framework taken up within MIROR project in understanding learning. This study will also serve as a contribution to the development of Variation Theory and its use as an analytical tool in a situation other than the traditional classroom situation.

Research Questions

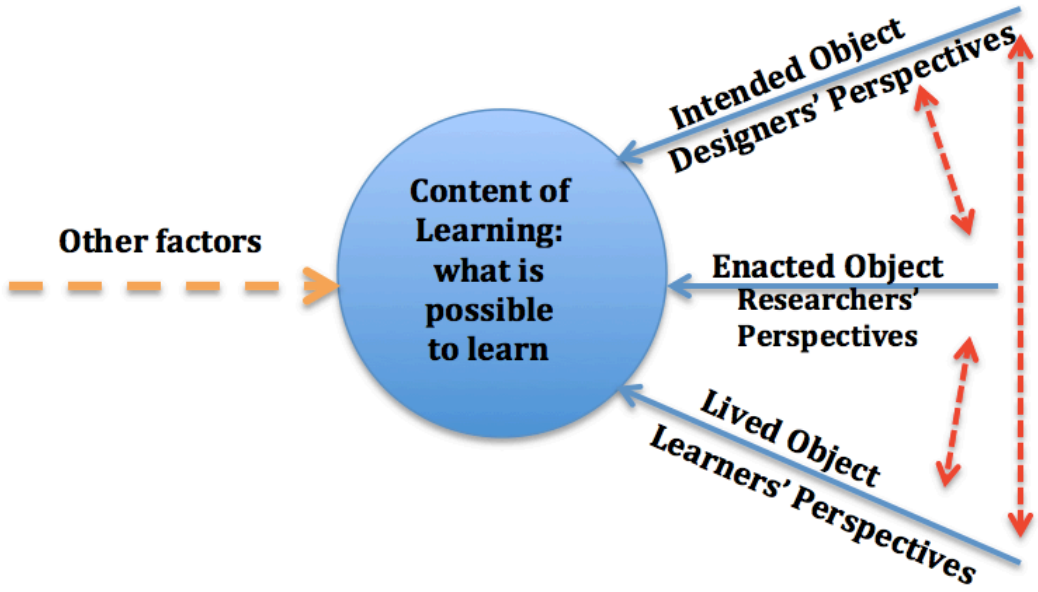


Figure 1. Content of Learning Diagram

The research questions addressed in this study include:

- What is the content of learning taking place in this learning situation as children interact with BG technology?
    - What is the intended object of learning?
    - What is the enacted object of learning?
    - What is the lived object of learning?

- How do the intended, enacted and lived object of learning relate to each other?
- What do children as research collaborators contribute to this technology?

An explorative goal free formative evaluation (Scriven, 1991) will be conducted in order to evaluate the actual effects of Body Gesture whether these were intended or unexpected. This type of research design involves outcome evaluation (Scriven, 1996), where the intended goals of the technology will be assessed with regards to if they are being met. The purpose of this assessment is to intentionally collect insight and feedback "as a basis for improvement" (Scriven, 1996, p.153). Additionally, this design also highlights any other undesirable or unanticipated events that must be taken in consideration for improvements to occur (Scriven, 1991). Therefore, since this evaluation is goal free I propose to also identify the presence of any other factors which seem to influence the possibilities of learning presented in this specific learning situation.

Chapter Two: Literature Review and Theoretical Framework

This literature review will entail an overview of research that: promotes the role of children as research collaborators; discusses technology and its impact on children's lives; examines technology based learning; evaluates music technology developed within the MIROR project; and illustrates the working of MIROR's newest technology, BG.

Children as Research Collaborators

Qvortrup (2004) points out that children have and are being seen as occupying "a waiting position" (p. 270), waiting to grow and mature into competent adults. Nonetheless, he points out that society and in particular researchers need to "prepare a *future childhood* that is worthwhile for future children to be waiting for" (Qvortrup, 2004, p. 270). Mayall (2001) suggests that we could achieve this by acquiring a deeper understanding of childhood as a social phenomenon through conducting research with children. This involves highlighting their social conditions, their own contributions to society and their social positioning in society (Mayall, 2001). This growing interest in understanding childhood brings with it ethical challenges and obstacles, which need to be addressed when conducting research with children. These range from parental consent, possible impact of participation, researchers' interpretation and representation (Dockett, Einarsdottir & Perry, 2009).

An ethical concern that is most problematic to this study is the duality present in today's childhood. As any other research participant, children have the right to give their assent, to be represented honestly in research (Dockett et al., 2009) and to be consulted in matters that affect their own lives (United Nations, 1989; Hill, 2006; Chitakunye, 2012). This affirms that they are active social actors. This status also pertains to younger children "as early childhood is recognized as a critical period for the realization of these rights" (Schiller & Einarsdottir, 2009, p. 125). However, young children's competency and maturity is at times questioned (Qvarsell, 2005). Some researchers fear that children are sometimes "termed as incompetent" (Mayall, 2001, p. 246) in expressing themselves in comparison with adult participants. This presents children as a subordinate group (Mayall, 2001), waiting to become competent adults. This contradictory duality needs to be taken into account to demonstrate that the young participants in this study are both worthy and mature enough to offer meaningful contribution. The cognitive maturity of this cohort of 7-year-old children will be discussed in the methodology against developmental psychology theories depicting the developmental milestones of typical 7 year olds. This will affirm that these participants are in fact able to discuss the learning situation presented in this study.

Despite this duality in childhood, research continues to demonstrate the benefits of conducting studies along with children, reinforcing children's rights to be consulted in matters affecting their lives (UNCRC, 1989, Article 12). One of these fields concerns the evaluation of technology. Burnard (2007) explains how crucial it is to consult the learners when evaluating and developing technology with the purpose of facilitating learning. Research with children in this domain acknowledges the child as active and facilitates the process of child empowerment (ibid.). This is also reflected in Laurillard et al., (2009) who refer to children as key stakeholders in the development of learning enhancing technology. Apart from benefiting children's status, user involvement is of utmost importance in confirming if the technology is

successful in producing the appropriate positive learning outcomes (ibid.). Therefore, this study proposes to respect children's rights of participation (Mayall, 2001) in research by giving privilege to their perspectives to explore BG's intended learning outcomes.

Technology and the Net Generation

Children's interaction with technology is not only restricted to evaluative research. Nowadays, children have increasing access to technology such as computers with internet, Ipad, television, and video games from a very young age. Due to their increased involvement, comfort and knowledge about new digital media this new generation has acquired the name of the net generation (Tapscott, 2009). Their increased involvement created a new kind of literacy within society, where children seem to be more competent compared to the adult generation (Tapscott, 2009). Vandewater, Rideout, Wartella, Huang, Lee and Shim's (2007) study reveals the typical digital activities per day of a cohort of 5 to 6 year olds in America. 78% of this cohort was reported to watch television for an hour and 19 minutes per day, 16% of this sample were reported to play video games for 55 minutes a day, whilst 27% of these children were reported to use their computer for 50 minutes per day. Since both Tapscott (2009) and Vandewater et al.'s (2007) studies suggests that technology has become part of children's lives they recommend further research investigating its effects.

Craft (2012) takes on this suggestion and illustrates that research concerning the effects of technology is divided between the "child at risk" perspective and the "empowered child" perspective. In her support of digital media, Craft (2012) explains that technology enables children to "develop their sense of identity, meaning, direction and even life course progress" (p. 176). Through networking, communicating, gaming, creating and sharing data children become empowered and "digital possibility thinkers" (Craft, 2012, p. 173). According to Craft (2012), the most important research question concerns what the technology enables children to do. In contrast with the empowerment perspective, other researchers have discussed how the use of technology is linked to physical ailments, emotional and social dysfunctions, and problems with intellectual and moral development (Cordes & Miller, 2000). Browne and Hamilton-Giachritsis (2005) also warn about the technology-induced risk of increased violent or fearful behaviour. Livingstone (2007) expresses a different take on this duality, claiming that both arguments are imperfect. The "child-centred" (p. 5) argument needs to reconsider the modest and context-dependent evidence, which frequently is used to generalize to the wide-ranging spectrum of technology. Furthermore, she argues that the "media-centred" (p. 5) argument should consider that since technology has become intertwined with our social lives it is inevitable for it to have some kind of influence.

As different as these two perspectives may seem, Bennerstedt, Ivarsson and Linderoth (2012) claim that they share a common assumption that interaction with technology, specifically games, inevitably results in the transferal of positive or negative outcomes to other aspects of gamers' lives. Contrary to this assumption, Bennerstedt et al., (ibid.) investigate the specific skills enabled by games, that are described as restricted to the gaming situation, through uncovering the gamers' own perspectives of their conduct. Influenced by both Craft (2012) and Bennerstedt et al., (2012) this study seeks to identify what BG enables children to do through investigating their own perspectives, without looking at the transferability of these skills. This anchors this study in between the child-centred and media-centred perspective.

Technology Based Learning

Research concerning technology-based learning is also characterized by the same costs and benefits debate concerning new digital media. According to Laurillard et al., (2009) what is common to most technologies is that they provide new learning opportunities with the benefits of introducing improvement to the educational institution. This innovation is described as stimulating students' intellectual expression and creativity as it presents professional skills in a new way that facilitates assimilation to practice (Laurillard et al., 2009). Similar to Laurillard et al. (2009), Webster (2011) presents technology as providing a new explorative approach to the learning of music that is different from the traditional imitation method present in traditional music education. Crow (2006) also contributes to this debate as he points out that music technology has the potential to encourage musical creative thinking in people who lack traditional music skills. This is achieved through "the technology's ability to manipulate audio" which makes it possible for people to "handle, create and communicate music using their computers" (p. 123, Crow, 2006). Similarly to Craft's (2012) empowerment perspective, this stance proposes that technology enables children's empowerment by allowing them to engage in personal musical choices. This results in musical learning through enabling children's creative expression (Crow, 2006).

On the opposite side of this debate, researchers challenge the claim that technology always presents children with a rich environment, which motivates the learning of professional and academic skills (Gee, 2003; Linderoth, 2010). Gee (2003) warns against the poor design of video games, which may hinder learning. Similarly Linderoth (2010) argues that video games provide tools that help players "gain access to performatory actions without having developed any skills" (p. 3). This results in players learning skills that are specific to the gaming world, which creates discrepancies between technology-based learning and the traditional educational sphere (Laurillard et al., 2009). This same discrepancy is also experienced between the fields of music technology and music education. Crow (2006) explains that children's everyday encounters with music are mostly by means of technology, which is very different from music introduced in schools. Wallerstedt and Lagerlöf (2011) explain this discrepancy by arguing that new music software such as eJay and Band-in-a-Box (Crow, 2006) have revolutionized what we regard as musical knowledge. This creates a problem in assimilating this new knowledge to traditional music education and for traditional musical skills to be useful and meaningful to the children's everyday lives. Instead of viewing this as a problem, Crow (ibid.) proposes that these new technologies can contribute to music education by making musical learning increasingly relevant to the children's everyday lives.

Unlike the other IRMSes, BG cannot as yet be discussed in terms of this cost and benefit debate since little is known about its possibilities of learning. Therefore, through illustrating its object of learning this study will contribute to this body of knowledge by providing insight into what BG enables children to do. These results will be discussed in relation to these two perspectives to generate insight into the learning possibilities or restrictions this new music technology introduces to the field of technology based learning.

MIROR Technology

Contrary to Crow (2006), Wallerstedt and Lagerlöf (2011) discuss that the technology's relevance to the children's everyday life is not always guaranteed when using music technology. This issue was brought up in their evaluation of music technology known as

MIROR Improvisation (Impro), designed within the same MIROR project as BG. This technology consisted of a computer and speakers connected to a synthesizer, which the participating children were encouraged to play. Previous studies concerning this technology have suggested that it created an interactive dialogue with the children (Addessi & Pachet, 2003; 2005; Addessi et al., 2006; Benghi, et al., 2008; Young, 2006). This was possible through the technology's ability to mirror their playing and reproduce it in the form of sound output heard from the speakers (Addessi & Pachet, 2003; 2005; Addessi et al., 2006). Addessi and Pachet (2003) describe this continuous pattern of child's input and technology's output as an interactive dialogue. MIROR Impro was also observed as adapting to the musical style and language of the player in order to serve as musical mirror (ibid.). Through observing the children's conduct, the researchers concluded that the children were indirectly learning certain musical skills such as musical creativity, expression, turn taking and developing a sense of a musical self (Addessi & Pachet, 2003; 2005).

These conclusions were not observed in Wallerstedt and Lagerlöf's (2011) study. Through interviewing the children, these authors found that they experienced this interactive dialogue as unusual and as differing from their previous experiences of music. Due to the children's unfamiliarity with the musical language and concepts introduced by MIROR Impro, they were not able to manipulate and benefit from this interaction. This research highlights the importance of investigating the children's own understanding of the technology. Similar to Wallerstedt and Lagerlöf's (ibid.) study, I propose to uncover critical insight on what BG enables children to do through exploring my participants understanding of this technology.

Apart from MIROR Impro the project designed and evaluated two further software platforms including MIROR Compo and BG. These technologies are all designed around the novel notion of Reflexive Interaction (RI) and are described as belonging to the Interactive Reflexive Musical Systems (IRMS) (Addessi & Pachet, 2003). This RI paradigm is responsible for enabling MIROR Impro to produce "musical samples" (MIROR_D2.2.1, p. 15) that mirror those produced by the player interacting with the technology. Through the use of intelligent mirrors the technology imitates the players' musical style and transforms the technology into a learning system which adapts to the player in real time. Even though MIROR Impro, Compo and BG are devised around this same principle, they each have individual properties that distinguish them from each other. As previously described, MIROR Impro mirrors the children's musical style when playing the synthesizer (Addessi & Pachet, 2003). MIROR Compo builds on this latter technology by enabling children to manipulate the recorded musical notes and melodies created when interacting with MIROR Impro to compose a melody. This is facilitated by presenting the children with visualization of both their previous musical inputs and the technology's replies. These visualizations can be edited and manipulated in order to experiment with the musical skill of composition. On the other hand, MIROR BG provides another form of interaction as it aims at enabling children to interact with the technology through moving their body instead of playing an instrument.

MIROR Body Gesture

Aside from its mode of interaction, BG has a specific architecture and is built on a unique concept. An underlying principle of this new technology originated from Rudolf Laban's work and his contribution to music and dance education (Bradley, 2009). In his theory of effort, Laban (1980) describes effort as the most important property of movement, composed of four components; space, time, weight and flow. The designers of this technology describe these components as dimensions with oppositional movement qualities on each end

(MIROR_D4.3.2). It is the combination of these four components and the many possibilities of movement along these dimensions that make movement both rich and expressive (ibid.). Similar to movement, music has its own dimensions and different qualities, which seem to correspond to these features found in movement (ibid.), such as the volume of a sound and the force put into making a step. Researchers in affective technology development have taken Laban's (1980) theory on board to create software with the ability to perform real-time extraction of information about the space, time, weight and flow from raw physical gestures (MIROR_D4.3.2). BG makes use of this new affective software, EyesWeb XMI, to transform this extracted information into sounds with similar qualities, by making use of analogies between movement and music. Its unique architecture consists of software connected to an Xbox Kinect and speakers. The Kinect tool is an input devise that captures the users' gestures through its motion sensors. This allows the users to control the computer and software through their gestures instead of using controllers or remotes. Its external tool (see figure 2) is positioned in front of the sensor with 3 paper cylinders of different colours on top of its deactivation shelf.

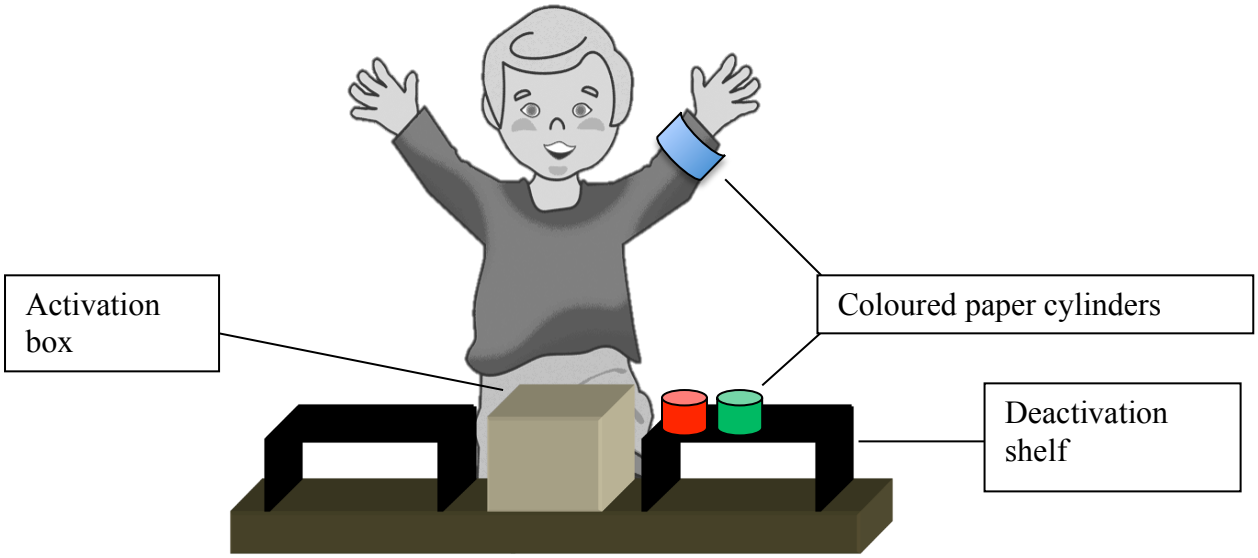


Figure 2. MIROR Body Gesture Physical Tools and 3 Coloured Paper Cylinders

Each paper cylinder represents a different sound that can be altered as the interaction progresses. The child is invited to stand behind the external tool and select a cylinder. When placed on the activation box, this cylinder is detected by the sensor, which triggers the production of a sample of the sound it represents. The cylinder can either be placed back on the deactivation shelf or it can be worn around the child's wrist. When worn, the cylinder is detected by the sensor, which activates the sound it represents and plays it continuously. The child is instructed to imagine he or she is holding a ball with his or her two hands and can move the ball down, up, left, and right, can bounce it to the floor, throw it to the ceiling, move it in circles, compress it against the activation box and stretch it to the sides. When the sensor detects these movements, the software extracts information regarding the gesture's space, time, weight and flow to translate them into sound with similar qualities. This creates variation in sound, as the child continuously introduces new movement. These changes in sound involve changes in the musical aspects of pitch, lateralization, density, distortion and dynamic accent. When the child is ready from their exploration of a particular sound they place the cylinder back on the activation box, stopping the sound.

Since little research has been carried out on this new addition to the IRMS group, there is little knowledge concerning the skills this music technology enables. Influenced by research promoting the involvement of children in research (James & Prout, 1997), that demonstrates children's valuable contribution to the field of evaluating music technology (Burnard, 2007; Wallerstedt & Lagerlöf, 2011) and research exploring what technology enables children to do (Craft, 2012; Bennerstedt et al., 2012), I propose to investigate what is possible to learn when children interact with BG, by studying what it is possible for them to discern from the variation of gestures and responding sounds they encounter while using BG. Designed around these above ideas, this study investigates what the designers intend the children to learn, the researcher's interpretation of the possibilities of discernment and the children's own perspectives on these possibilities of learning. This insight will in turn contribute to the body of knowledge of technology-based learning and generate feedback for the purpose of improving this new technology.

Theoretical Framework

In this section the central concepts of Variation Theory will be illustrated. Firstly the content of learning will be deconstructed to demonstrate what each object of learning entails. This will be followed by a description of what is meant by learning and by taking the second order perspective. Important concepts for learning will also be discussed, which will include important terms such as the critical aspects, patterns of variation and external and internal horizons of the lived object of learning.

From a Variation Theory perspective learning always involves "the acquired knowledge of something" (Marton & Tsui, 2004, p. 4). This content learnt is described as the object of learning and entails both knowledge discerned and capabilities developed. This concept of the object of learning is shared by both Variation Theory and research concerning music education and technology. Similar to Marton and Tsui (2004), Crow (2006) argues that researchers need to focus on "what musical learning takes place when pupils engage in music activities" (p. 124). Variation Theory presents a way of capturing this object of learning by comparing the teacher's perceptions of what they set out to teach (the intended object of learning), the perception of the researcher of what he or she observes as happening in the learning situation (the enacted object of learning) and the learners' perspectives of what they learn (the lived object of learning) (Holmqvist, Gustavsson & Wernberg, 2009). Thus, by making use of Variation Theory as the theoretical framework and analytical tool, I will contribute to research concerning technology based learning by shedding light on the learning potential brought forward by a new music technology. This will be done through investigating what knowledge can be learnt and what capabilities can be developed when interacting with BG, through highlighting the intended, enacted and lived object of learning (Marton & Tsui, 2004).

As previously mentioned, Variation Theory focuses on the second order perspective as it seeks to uncover the learners' experiences (Marton & Booth, 1997). Emerging from phenomenography, Variation Theory shares its focus of investigating the different ways people experience a given phenomenon (ibid.). However, this second order perspective is not only shared with phenomenography since it features in other different branches of research including anthropology, history and philosophy of science studies (ibid.) It has also been used within research concerning nursing where researchers have gained insight into the different ways nursing students experience their education, the different ways patients experience their

diseases, situation and needs and how this insight can influence the curriculum guiding nursing education (Sjöström & Dahlgren, 2002). Tomm (1998) also describes how family therapy studies also make use of this second order perspective in understanding the family system through investigating how the family members' different ways of seeing phenomena influences specific patterns of interaction within their families.

This second order perspective concept is also evident in research within the field of technology, as Burnard (2007) discusses that the users' experiences are in fact central to evaluating technology. However, this second order perspective seems to be missing in previous research within MIROR project (Addessi & Pachet, 2003; 2005; Addessi, et al., 2006; Benghi, et al., 2008; Young, 2006), as researchers have taken up a different conceptualisation of learning that perceives the interaction created between child and technology as the critical indicator of learning (Addessi & Pachet, 2003; 2005). The benefit of using the second order perspective in research is demonstrated by Wallerstedt's (2011) study concerning music listening and learning. Through using Variation Theory, Wallerstedt (2011) explored young students' ability to discern musical time or metre during a music lesson. Through exploring the lived object of learning, Wallerstedt (ibid.) demonstrated that during the lesson the students were not aware of this intended musical aspect. This inconsistency between the students' and teacher's perspectives could have gone unnoticed without taking on this second order perspective. Therefore, this study demonstrates how Variation Theory can contribute to the previous MIROR research by uncovering the learners' perspectives and any discrepancies with the intended object of learning.

Since the main premise of this thesis concerns learning it is of utmost importance to illustrate the conceptualization of learning brought forward by Variation Theory. When people encounter a situation, they become aware of certain aspects, attributes and features (Marton & Tsui, 2004). If we listen to a song certain features of this song may become evident, such as its melody and tempo. As we focus our awareness on these features, they occupy the fore of our awareness. Marton and Tsui (2004) describe this process as discernment as we learn to identify, distinguish and understand these features. Since a phenomenon has a multitude of features people can vary with regards to what they attend to. This variation is attributed to the different meanings each person attaches to a given situation, shaping their understanding and learning (Marton & Tsui, 2004). On the one hand, if a non-musician listens to a nostalgic song he or she might attend and discern its lyrics and emotive stance. On the other hand, if a musician listens to the same song, he or she might be more inclined to discern structural and technical aspects of the song.

What does this mean to educators and designers engineering learning enhancing technology? This implies that Variation Theory can be used to design technologies around features or more precisely critical aspects (Marton & Tsui, 2004) that are the most important for the students to discern in order to develop a desired understanding. When these critical aspects are identified, it becomes essential to create possibilities that assist the learners to become aware of them and thus discern them (Marton & Tsui, 2004). One of the most important possibilities highlighted by Variation Theory consist of patterns of variation and invariance (Marton & Tsui, 2004). Therefore, if a teacher wants her students to listen and attend to the pitch of a guitar playing she or he must introduce variation. Whilst holding the tempo, tone and melody constant, the educator must play a low pitch note and then vary this note to introduce a higher pitch. Seeing that pitch is the only varying musical aspect, the students' awareness will most likely shift to focus on this aspect whilst other aspects such as tempo, tone and melody recede to the ground of their awareness (ibid.).

However, not any variation will suffice as Marton and Tsui (2004) describe that there are specific patterns in which variation can be organized. These include the patterns of contrast outlined above, the pattern of separation that entails the variation of one aspect, the pattern of fusion that entails variation of more than one aspect at one time and the pattern of generalization. This latter pattern involves presenting the same variation in the critical aspect of pitch using a different sound (ibid.). Since BG and Variation Theory have this mechanism of variation in common, this theory becomes a powerful way of understanding this technology. Therefore, apart from providing insight into designing technology, Variation Theory can also be used to evaluate and examine the results of using a given technological platform. This latter property of Variation Theory will be used in this study to analyse what patterns of variation are presented to the participants and illustrate what aspects and features the participants could have possibly become aware of when using BG. This will be compared to the designer's learning intentions in order to evaluate if the technology enables the participants to become aware of the intended learning.

Another possible way to increase awareness of the critical features involves the teachers' role and the language she or he uses (Wallerstedt, 2011). Asking questions has proven to be crucial to divert the students' attention towards the critical features and to also identify what the students are focusing on (ibid.). "(D)ialogue seems as an arena for the meeting of the intended and lived object of learning" (Wallerstedt, 2011, p. 117). This dialogue is especially useful with regards to music learning since Pramling and Wallerstedt (2009) describe this music domain as tinted with communication challenges as learners are expected to transduce from an auditory to a verbal modality. Children in both Pramling and Wallerstedt (ibid.) and Wallerstedt's (ibid.) studies were observed as using signs, gestures, symbols and familiar words to cope with this demand (Wallerstedt, ibid.). However, both studies highlight the essential role teachers play in providing the vocabulary or institutional terms (Pramling & Wallerstedt, 2009) needed to effectively describe the different musical aspects. This common vocabulary ensures that the students' and teachers' awareness coincide.

In order to make this comparison between the students' and teachers' awareness in this study, a method to represent the learners' perspectives must be established. Through listening and analysing the self-talk of a girl who interacted with a computer simulated graph creator, Runesson (2006) presents a way how researchers can gain access to the learner's motivations and uncover the external and internal horizons making up the lived object of learning. The external horizon involves the context that is perceived by the learner as surrounding the phenomenon being learnt whilst the internal horizon encompasses the different features making up this phenomenon (Lo, 2012). This concept of horizons has been previously introduced by hermeneutics philosophers who describe horizons as "a range of vision that includes everything that can be seen from a particular vantage point" (Gadamer, 1975, p. 301). From this perspective, understanding or learning involves the development of one horizon, or as Gadamer (1975) describes it a context of meaning encompassing meaningful presentations, to another horizon that includes previously known meaning and new and unfamiliar elements. These descriptions are similar to how Variation Theory presents the concept of horizons as each external and internal horizon represents the learners view or understanding of this technology, whilst also acknowledging the movement possible from one horizon to another. Table 1 presents hypothetical examples of how the participants in this study can perceive both the external and internal horizons surrounding BG.

	External Horizon	Internal Horizon
Perception A	Technological system	Kinect, speakers, microphone, computer
Perception B	Music	Melody, sounds, harmony

Table 1. External and Internal horizon of the object of learning

The participants can perceive BG as embedded in the context of technology, a context concerning music or school. As demonstrated in Table 1 these hypothetical examples show how the perceived contexts influences what different features the learners become aware of. These different features making up the internal horizon of the lived object of learning, shape the meaning given to this technology whilst also shaping the perceived context surrounding BG. This possibility of identifying the external horizon and internal horizon presented by Variation Theory will shed light on what the participants are aware of and hence what is possibly learnt or discerned (ibid.). It is crucial to note that Variation Theory claims that the lived, intended and enacted objects of learning are characterized by a dynamic nature. This means that different people will have different and distinct experiences that change over time (Marton & Tsui, 2004; Lo, 2012). It is also common to experience differences between the lived and intended object of learning in a learning situations (Lo, 2012).

Whilst the concepts introduced by Variation Theory outlined above present adequate tools in understanding BG, it is important to note that certain concepts are also discussed in other theories and approaches. Apart from the theoretical parallels found in phenomenography, the concepts of shifts in awareness, variation and discernment are also present in earlier work of Gestalt psychology. The previous example of listening to a nostalgic song will be used in order to highlight these similarities. When a person listens to a nostalgic song or as Koffka (1922) explains a music stimulus, a sensation is produced in the listener. Similar to Variation Theory, these sensations can vary depending on what content making up the stimulus the listener attends to (Koffka, 1922). Therefore, a musical stimulus may not always result in the expected or intended sensation due to the variation in the listeners' attention. These concepts are echoed in Variation Theory's concepts of the dynamic nature of the lived object of learning, its relationship to the intended object of learning and the role of the learners' awareness in discernment. Additionally, in Gestalt psychology an auditory stimulus is divided into two phenomena, the figure and the ground phenomenon (Koffka, 1922). Before the teacher plays the nostalgic song, the students are most probably listening to constant background noise made up of the street traffic outside the class window, the chatter of the other students and the occasional pencil falling from their desk. Koffka (1922) describes this constant sound as the auditory ground that the students are not especially attentive too. However, when the nostalgic song plays an alternation to this ground is perceived, as the figure phenomenon is introduced. This alteration presented by the figure grasps the students' attentive (Koffka, 1922). It becomes clear that these concepts introduced in Gestalt psychology are reproduced in the concepts of invariance, variation and their influence to discernment. However, even though these theoretical parallels exist, Variation Theory seems to add on to these concepts by identifying different types of patterns of variation that can best capture the students' awareness, helping educators to evaluate learning and design learning situations.

In conclusion, Variation Theory equips this study with tools to uncover the content of learning through making use of the second order perspective, examine the different patterns of variations occurring in the learning situation and comparing them to the external and internal

horizons identified by the participants. This will allow me to identify what possibilities of learning are presented in the enacted object of learning, if the learners are aware of these possibilities of learning, what features the learners are aware of and how does this relate to the intended understanding identified by the designers of BG. Inspired by Wallerstedt (2011), who provided the only depiction of the effectiveness of this theoretical framework in investigating musical learning, I propose to provide new insight on what is possible to learn when interacting with BG. This will in turn contribute to the knowledge base of technology-based learning, as it will provide new insight into the learning possibilities or restrictions offered by this new music technology.

Chapter Three: Methodological Design

The methodological design chapter will present the research design and its qualitative mixed methods used, including the analysis of primary documents, of video recorded arranged learning situation and semi-structured interviews with the participating children. These methods will be discussed with reference to how they fit in the MIROR project and also how they make this study distinct from this same project. To conclude the ethical consideration when conducting research with children will be discussed.

Research Design

A goal free formative evaluation research design (Scriven, 1996) was employed in this study. Formative evaluation seeks participants' feedback for the purpose of improving what is being evaluated (ibid.), in this case BG. This design is also goal-free since it sheds light on both expected and unexpected outcomes (Scriven, 1991), to facilitate the development and further improvement of BG. This design also affirms children's active role as research collaborators. The importance given to their perspectives also serves to reinforce the emerging "idea that children should have a voice in decision making" concerning "their lifeworld and their environment" (Lange & Mierendorff, 2009, p. 85). In addition this research design falls under what qualitative heuristic methodology recognize as an explorative study as it proposes "openness of the research person", "openness of the research topic", "maximum variation of perspective" (Kleining & Witt, 2001, p. 6) and "discovering similarities and integrating all data" (Kleining & Witt, 2001, p. 7).

As collaborators within the MIROR project, UGOT had the responsibility to conduct a one-group post-test only quasi-experiment (Hartas, 2010) in October 2012. During this experiment two different programs of BG were evaluated, which are known as The Potter and Be Sound. The team also conducted semi-structured recall interviews with the participants a week after the experiment. As a member of UGOT, I was involved in the data gathering of this study along with Åsa Bergman. This data was collected and analysed in order to present an evaluation of BG to the different partners within the MIROR project. Although this thesis is part of UGOT's contribution, within the frame of the project that aims at evaluating different IRMS, it provides a different scope than that determined in MIROR. It concerns the exploration of only one programme of BG, known as The Potter. This focus is due to the nature of both programmes, as The Potter was in its final stages of development whilst Be Sound was an initial prototype at the time of the quasi-experiments.

In this study, data gathered from the video recorded quasi-experiment and interviews concerning The Potter were reanalysed from a Variation Theory perspective and compared to new data gathered from analysing primary documents. A mixed method approach was employed for its advantage of illuminating different aspects of the phenomenon under study (Hartas, 2010). Thus, by observing the quasi-experiment concerning The Potter, analysing the semi-structured recall interviews and analysing primary documents developed within MIROR project, I will shed light on the enacted, lived and intended object of learning. Since this study takes on a qualitative stance the quasi-experiment is referred to as an arranged learning situation in order clarify my intentions of describing the occurring learning opportunities rather then proving causation (Hartas, 2010).

The primary documents.

Documents developed within the MIROR project written and edited by the original designers of the BG were analysed to illuminate the intended object of learning. The documents were selected on the basis of their content that must concern the IRMS paradigm, BG and specifically The Potter. These selected documents provided the most detailed and relevant information about the technology and its learning goals. Qualitative content analysis (Bryman, 2004) was used in order to search for themes throughout the different selected documents. The main themes which were extracted from the documents include the specific and general aspect of the intended object of learning (Lo, 2012). The specific aspect describes what knowledge the designers expect the learners to acquire whilst the general aspect sheds light on extra capabilities that the designers expect children to develop as a result of the technology (Lo, 2012). This intended object of learning was compared to the enacted and lived object of learning to discuss if the learners discerned the expected knowledge and capabilities.

Although this method provides insight into a segment of the object of learning it also brings along several limitations. Bowen (2009) explains that when using document analysis there is always a risk of not collecting sufficient detail or missing out on important documents due to lack of accessible. This may lead to selectivity bias where the researcher has an incomplete collection of the necessary data (ibid.). Having said so, this research method was more suitable then its alternative method of interviewing all designers involved in the development of BG. These interviews would have been very time consuming without the possibility of conducting face-to-face interviews since the participants include a number of international designers. Moreover, the needed data to answer the research question regarding the intended object of learning have already been produced and organized in public deliverables, written within the context of assisting the reader to understand the learning potential of BG and its learning goals. Therefore, document analysis seems the most suitable research method that provides the necessary data for this study's aims.

The arranged learning situation.

Two researchers from UGOT, Åsa Bergman and I, have collected approximately 3 hours of video-recorded data, where a group of 6 and 7 year old children interacted with 2 different programmes pertaining to BG. The sample for this arranged learning situation was selected through convenience sampling, as a Swedish primary school that had strong connections with UGOT was asked to participate. This type of sampling method brings along several limitations and implications to the results that can be drawn from the gathered data (Suri, 2011). Since convenience sampling recruits participants who are available and willing, it opens up this study to sampling bias (Wallen & Fraenkel, 2000). Consequently, the researcher cannot claim that the selected sample is representative of the greater population (Wallen & Fraenkel, 2000). The implication of this bias includes the lack of population generalizability, where the results gathered from this study's sample cannot be extended to the wider population of other 7 year old children, which in turn limits the study's external validity (ibid.).

Having said that, Corbin and Strauss (2008) denote that although it brings about unfavourable limitations at times researchers choose this type of sampling when the study aims to look into people or situations that will give them access to specific data. In line with this motivation,

since this school and the majority of the children in the sample had already participated in an earlier pilot study of BG, they had already acquired some familiarity with the technology needed in order to operate the technology with greater ease than beginners. Additionally the willingness of the participants was also important since both the researchers were looking for the children's assent. Additionally as Wallen and Fraenkel (2000) explain at times random sampling is not practical or realistic given the financial, time and resource limitations. This was also the situation in this project where a certain framework was employed and adjustments to this framework were not possible due to the mentioned above restrictions and limitations. Nonetheless, these limitations will be taken in account when discussing the data gathered from both the arranged learning situation and the recall interviews and the underlining results.

Consent forms were sent out through the school, where both guardians and children were asked for consent and assent to participate. Another child who is a relative of a researcher in UGOT volunteered to participate and also signed the same consent form along with his guardians. This research study focused on analysing data pertaining to The Potter, with a total of 1 hour and 30 minutes video-recorded data. This arranged learning situation took place in a lecture room at the University of Gothenburg, were two technicians from University of Genoa, two researchers from UGOT and a group of 6 children accompanied by their teacher participated in evaluating BG (Appendix 2.1). Before the arranged learning situation the children were all debriefed about the days' events and also participated in a 20 minutes warm up session that I led (Appendix 2.2). The purpose of this session was to help the children familiarize themselves with the researchers and for the researchers to introduce the movements and gestures afforded by the technology. After the warm up activities I gave the participants a demonstration of how to use the technology and informed them of the intended procedure encouraged by the designers of BG (Appendix 2.3). Afterwards, the children interacted with the technology individually (Appendix 2.1).

During the arranged learning situation I took the active role of serving as a mediator between the technicians and children, by prompting and guiding the children when faced with technical errors and by answering children's queries. My active involvement could have easily influenced the children's conduct. However, since the technology could only detect specific movements and required particular procedures to function, the information passed through my involvement was essential for the children to operate this technology.

Observation method was employed to produce detailed descriptions of the children's gestures and the technology's sound reactions during the arranged learning situation. This uncovered the enacted content of learning that highlights the patterns of variation occurring in the learning situation. Kendon's gesture analysis (1997) was modified and used to transcribe the interaction between child and technology. This mode of analysis originally focuses on the connection between gestures and speech (Kendon, 1997). However, this later component was replaced by sounds, since the technology responded to the children's gestures through sounds. Each child's interaction was transcribed individually creating tables such as table 2. The tables consist of two columns representing children's gestures and the corresponding sounds produced by the technology, whilst each row represents the same instance occurring during the interaction. The technology is able to detect a limited number of movements, which in turn have limited sound responses. These affordances illustrated in table 3 were used to transcribe the interactions.

Child A	
Gesture	**Sound**
Hands up	High pitch

Table 2. Sample of Transcript

Sound Parameters	Variation in Sound	Variation in Gesture
Pitch	High pitch	Hands up
	Low pitch	Hands down
Lateralization	Left direction	Hands left
	Right direction	Hands right
Dynamic Accent	Percussive attack	Sharp bouncing gesture vertical movement
	Slow attack	Smooth gesture vertical movement
Density	Low density	Compression: hands compressed against each other in front of child
	High density	Stretch: hands open horizontally on opposite sides
Distortion	Strong Distortion	Strong and effortful hand compression and hand stretch; compressing hands against activation box
	Weak Distortion	Smooth and effortless hand compression and hand stretch

Table 3. Affordances of Movement and Sounds of the Technology

Once the interaction was transcribed Variation Theory was used as an analytical tool to identify the different patterns of variations present during interaction in order to identify what learning opportunities are presented by the technology and if these opportunities present possibilities for the intended learning. Furthermore, this enacted object of learning was compared to both the intended and lived object of learning. The data analysing software 'The observer' was used to analyse the most interesting and informative snippets from the transcripts and present them in visualizations that visually depict the variation in the movements against the sound responses or absence of responses produced by BG (Appendix 3). These visualizations will be used in the results section to facilitate the understanding of the different patterns of variations occurring during the arranged learning situation.

Although observation is one of the most popular methods in qualitative research (Hartas, 2010), it has been criticised as being subject to research interpretation and of having little possibility of conducting member checks (Mulhall, 2003), decreasing the internal validity and credibility of the study (Shenton, 2004). These shortcomings may risk the generalization and transparency of research findings (Bryman, 2004). An alternative method identifies that could also capture the interaction occurring between child and technology included conducting a structured observational measure. Meyer, Cash and Mashburn (2011) recommend the use of CLASS to measure the quality of teacher-child interaction by scoring the interaction against items concerning emotional support, instructional support and classroom organization. This measure might have been altered in order to make it appropriate to observe and record

interaction with a technology instead of a teacher. However, since this study aims at capturing both expected and unexpected outcomes this method would have been restrictive, especially since this interaction has not as yet been researched or theoretically known. Therefore, unstructured observation was the most suitable method in capturing this type of interaction and answering this study's research questions. Nonetheless, the limitations it brings will be discussed in relation to how they can influence the results and insight obtained.

The semi-structured recall interview.

The participants were interviewed a week after the arranged learning situation, where a researcher met the children at their own school and showed them snippets of the video data whilst asking a series of questions. The other participant who did not attend the same school was interviewed in his own home. This type of interviewing involves video-stimulated recall, where the participants are shown a recorded activity that they have partaken in, in order to recall their experiences, comment on said experience and stimulate discussions (Rowe, 2009). This method allows the participants view the recorded experience or interaction with an outsider's perspective whilst also holding knowledge with regards to their original intentions and motivations (Clarke, 2002). Coupled with semi-structured interviews this method allows the researcher to follow emergent ideas introduce by the participants as the discussion ensues, giving more freedom than structured interviews or questionnaires (Rowe, 2009). However, it also has its limitations as Dempsey (2010) explains that communicating about interaction is not always easy especially if it concerns music or sports. Therefore, participants could struggle with finding the language to describe the happenings, restricting the researcher's access to their meanings and experiences (ibid.). An alternative method identified entails using thinking aloud techniques that involves the participants talking about their experienced in real time (ibid.), used in Runesson's (2006) study concerning the interacting between a girl and a computer simulated graph creator. Nevertheless, this method presents its own limitations as the self-talk might influence the interaction itself (Rowe, 2009). Therefore, taking in consideration the above limitations and advantages the video recall semi structured interviews seemed to be the most suitable method in answering the study's research questions.

Åsa Bergman and I designed these recall semi-structured interview, with the aim of asking similar questions to each participant whilst providing flexibility by using open-ended questions. This was done in order to provide enough space for each participant to share his or her thoughts. Each participant viewed snippets pertaining to their own sessions, which were selected beforehand by the researchers. The interviews were audio recorded, transcribed as "verbatim accounts" of what was said in the interview (Poland, 1995, p. 291) and translated to English by Åsa Bergman.

The interview method is the most common method used in phenomenography to tap into the distinct ways in which people conceptualize a phenomenon (Marton & Booth, 1997). Variation Theory follows suit and encourages the use of post-lesson interviews to understand what students think of the learning that occurs (Lo, 2012). The recall interviews conducted are similar to post-lesson interviews because they occurred after a learning situation and elucidate the second order perspective. As previously mentioned in the theoretical framework, the lived object of learning is made up of the external and internal horizon. These aspects were identified through analysing how the children spoke about the technology and the occurrences in the snippets shown. The language used by the participants to describe the different patterns of variations and changes in sound were also highlighted and analysed.

This lived object of learning was compared to the intended object of learning, which ensued a discussion on whether the goals set by the designers of BG were discerned by the participants. It was also compared to the enacted object of learning, to illustrate how the participants experienced the possibilities of learning made possible by the technology. Therefore, through analysing the intended, enacted and lived object of learning the intended learning, the possibilities occurring in the learning situation and most importantly the participants awareness of these learning opportunities were highlighted to evaluate what BG enabled these children to do (Craft, 2012).

Ethical Considerations

Throughout the data collection I followed The Swedish Research Council Ethics Code (Codex, 2012), as I collected informed consent from guardians and assent from children through giving out consent forms. The participants were also informed of their right to withdraw from the study at anytime. Their identities were protected and confidentiality assured through using pseudonyms and restricting the viewing of the video recorded data to the research team at UGOT. The participants' thoughts and voices were represented through employing a formative evolution design. Therefore, even though other data sources such as primary documents and video-recordings were used, priority was given to the learners' perspectives and feedback. This will enable the participating children to have an impact on the technology's evaluation and development (Hartas, 2010).

The participants were involved as collaborators in both data generation and analysis in order to highlight the second order perspective aimed for (Dockett et al., 2009). By interacting with the technology the participants in this study generated the needed data. They were also involved in analysing the video-recorded data through providing their own interpretation of the enacted object of learning to uncover the learners' perspectives. This learners' perspectives is similar to the children's perspectives referred to by Sommer, Pramling Samuelsson and Hundeide (2010). Whilst the child perspective involves the researchers reconstruction of the children's experiences, the children's perspectives concern the children's own experiences and meaning (Sommer et al., 2010). Similarly, this study provides the learners' own experiences and meaning rather then the researchers' sole interpretation.

Another ethical issue that surfaces when conducting research with children is the issue of representativeness. Dockett et al. (2009) argue that a researcher needs to first acquire an understanding of the participants' context before they can understand the meaning beneath their sample's contribution. In this study this understanding of context is acquired through analysing the participants' language when describing the learning situation, especially when making references to their own previous experiences. This analysis forms part of the external horizon of the lived object of learning, which enabled the discussion of the difference between the intended context and the lived context. Therefore, through capturing the children's external horizons, this study will assure that these participants' experiences will be represented.

As mentioned previously in the literature review, the focus on the learners' perspectives brings about ethical issues involving children's maturity and competence. Mayall (2001) discusses that children are sometimes perceived as incompetent in expressing their ideas and contributing to research. Researchers are advised to take in consideration the children's maturity before involving these participants in research (UNCRC, 1989, Article 12). These worries stem from the perspective that views society as depending on competency (Mayall,

2001). From this perspective, people are seen as moving through stages of development as they grow older, increasing their competence through maturity and education (Berk, 2006). The participants in this study, who fall under the age group of 7 to 11, are described as situated in the concrete operational stage. According to developmental psychologists Inhelder and Piaget (1958), this group is able to think concretely about tangible aspects such as real concrete experiences. Hence, from this perspective the participants in this study are theoretically perceived as either able to discuss or are developing the ability to talk about their real experiences. This makes them competent enough to fulfil the requirements of this study of communicating about a concrete learning situation. Nonetheless, during the semi-structured recall interviews the participants were aided in expressing themselves by presenting actual video clips of their own interaction with the technology.

Chapter Four: Results

This chapter will illustrate the results collected from the document analysis, learning situation with BG and interviews with the participating children. The following discussion will be divided in three sections where the intended, enacted and lived object of learning will be illuminated.

Section 1: The Intended Object of Learning

In this section I will tackle the first research question regarding the intended object of learning gathered from the designers' perspectives of the learning goals proposed by BG. This intended object of learning was gathered from the analysis of primary documents within the MIROR project deliverables. These results illustrate the theoretical underpinnings of BG's principles and expected outcomes from the designers' perspectives to shed light on what capabilities are expected to develop through interacting with BG (Marton & Tsui, 2004). Variation theory will be used to organize this presentation in two segments, each representing a part of the anatomy of the object of learning. Firstly, the general aspect will be disclosed, highlighting the nature of the expected capabilities and the way children are expected to go about learning them (ibid.). This will follow a discussion of the specific aspect that deals with the expected content to be learnt (ibid.). These two different aspects will be combined together to present a complete depiction of the intended object of learning as conceptualized from the designers' perspectives.

The general aspect.

The Interactive Reflexive Musical Systems (IRMS) are described as new technologies designed around common Reflexive Interaction (RI) principles with a collective aim of stimulating users' attention towards music and movement. The overarching goals of these technologies involve the stimulation of "content creation processes" (MIROR_D2.2.1.P1, p. 6), such as the abilities of problem solving, building musical structures and expressing self by the use of sounds. Since BG belongs to this IRMS group, the nature of its' expected capabilities are of a similar nature and involve acquiring certain awareness of and sensitivity towards specific sounds, expressing oneself, problem solving and constructing in relation to music and movement (MIROR_D4.3.2). These capabilities are known as the indirect object of learning, and refer to the type of capabilities the users of the technology are expected to master (Marton & Booth, 1997).

These capabilities are believed to develop through the use of Reflexive Interaction principles central to the different IRMS. These principles include repetition, variation and mirroring and are what Marton and Booth (1997) refer to as the act of learning, depicting how the capabilities are carried out and learnt. Repetition enables BG to mimic the different gestures introduced by the child and produce sounds that are characteristically similar to these gestures. Therefore, throughout the interaction process, the children are faced with an auditory mirror of themselves or more precisely of their movements. This experience of mirroring is said to be of a familiar nature to children, as the designers explain how imitation is characteristic of the mother infant relationship (MIROR_D2.2.1).

The variation principle reinforces this similarity between technology initiated mirroring and mother mirroring, by introducing imperfections to the imitation. This imperfection is described as characteristic of human imitation and thus creates a closer similarity to mother mirroring. This is done in the hopes of taking advantage of the benefits associated with mother-infant imitation, that are regarded as beneficial to the children's development in the field of developmental psychology. Stern (1977) portrays the mothers' use of imitation as a way to attract the children's attention, creating a mirror through which the child can become aware of rhythm, musical structure and shape (Papousek, 1995, cited in MIROR_D2.2.1.P1). This results in the development of what the designers describe as the "musical self" (MIROR_D2.2.1.P1, p. 11) and might result in the development of their self-identity. With regards to the capabilities to be learnt, repetition and variation in BG are promoted as ways to stimulate awareness towards the technology and consequently to the sounds it produces (MIROR_D4.3.2). Similarly to mother infant relationship, the technology's use of mirroring is aimed at increasing its attractiveness and motivate the children to participate in the interaction (Pachet, 2002).

Another RI principle influencing the way children go about learning the intended capabilities is the promoted approach of exploration. When interacting with BG, the children are expected to explore the different movements and sounds available. This exploration is described as free from restrictions such as adult initiated rules or objectives, as children are left free to co-construct their own objectives spontaneously. This way of learning is described as supporting children in sharing musical and movement ideas and in promoting musical and motor expression and invention (MIROR_D4.3.2). Therefore, this act of learning is described as contributing to the capabilities of expressing oneself and of building musical structures.

When comparing these acts of learning promoted in BG to learning conditions promoted by Variation theory, the principle of variation seems similar. However, its use in IRMS is somewhat different to the concept used in Variation theory. Marton and Tsui (2004) describe variation as a necessary condition for learning. In order for us to become aware of something in our environment it needs to vary, making it visible and possible for us to discern it. This continuous process of experiencing variation and discernment contributes to a more powerful way of seeing the world as more objects or aspects become known to us (ibid.). An example of this variation concerning music involves a music teacher who varies the tempo of a song in order to concentrate children's attention on this aspect (Wallerstedt, 2010). In order for this variation to be successful, the children need to experience contrast, where an aspect must be compared to what it is not in order for it to become visible and to acquire meaning (Marton & Tsui, 2004). Thus variation, in the dimension of tempo, involves experiencing fast and slow tempo and experiencing contrast between these two features.

This purpose of variation is very distinct from the designers' perception of variation and its' use of producing imperfections in imitation. This difference in purpose creates fundamental differences in the nature and structure of the variation presented to children throughout their interaction with BG. Whilst variation in Variation theory has an aspect (e.g. fast/slow tempo) as its goal, variation in IRMS-technology is used to stimulate users' attention and interest on a more general level. This indicated that, the designers' understanding of what is necessary for learning is distinct form that understood by Variation theory. According to Marton and Tsui (2004) not any variation will suffice and therefore different patterns of variation need to be organized systematically to facilitate discernment. An example of this order would entail introducing the pattern of contrast before the pattern of generalization and of initiating the pattern of separation of aspects before fusing them together. It becomes significant to

investigate how the nature of variation presented by the technology, influenced by the designers conceptualization of learning, will impact the possibilities of learning the stated above capabilities of acquiring awareness of specific sounds, expressing oneself through sound, building and inventing musical structures, and problem solving. Apart from variation, the learners are expected to use repetition, mirroring and exploration as ways to go about their learning. Therefore, it becomes significant to investigate how all these acts of learning making up the general aspect of the intended object of learning impact the possibilities of learning the indirect object of learning. To expand our understanding of what is intended to learn, we must now redirect our discussion towards the content on which these capabilities are carried on (ibid.).

The specific aspect.

Another important part of the intended object of learning is known as the specific aspect that concerns what content the children are expected to learn (Marton & Tsui, 2004). This was uncovered through illustrating what the designers' highlight as the content of learning and the knowledge the children are expected to learn after interacting with BG. This content is described alongside Variation theory's concepts, to further understand its nature and its expected impact on the possibilities of learning. This involves a discussion of both the musical aspects and features identified as significant by the designers, in order to identify the dimension of variation opened up and the different values within these dimensions respectively (Lo, 2012). Furthermore, the structure of the patterns of variation promoted will be illustrated in order to investigate how variation is expected to surface during the interaction and its possible impact on learning. The nature and structure of this specific aspect will be utilized when investigating the enacted object of learning, to explore if the participants in this study have the possibility to learn what is intended.

BG's specific aspect concerns sound morphology. This refers to different musical features, structures and characteristics that differentiate a certain sound or music from another (Young, 2004). The sound morphology addressed in BG includes pitch, lateralization, dynamic accent, distortion and density. These sound features are identified by the designers as the critical aspects since they have acknowledged these musical aspects as the most important to discern in order to achieve a more powerful way of understanding music. Thus, the technology is designed to introduce variation in these critical aspects, producing dimensions of variation corresponding to each. The designers describe variation as the necessary act of learning that stimulates the children's attention towards these critical aspects and thus making them visible. From a Variation theory point of view, this is so because the children can only become aware of pitch if they perceive a change in sound related to pitch (Marton & Tsui, 2004). If the sound remains the same then its discernment is not possible.

This variation is activated and controlled by the children. This is possibly due to the technology's use of "movement detection and feature computation" (MIROR_D4.3.2, p. 33), which detects specific hand movements performed by the child. The quality of the movement is extracted and processed by the "movement analysis module" (MIROR_D4.3.2, p. 33) and translated to Laban's Effort components. Here the movements' weight, time, space and flow components are calculated. Each component is made up of a spectrum of different values, with weight varying from heavy to light movement quality and time varying from fast to slow movements. Each of these values within the components corresponds to a particular value within the aspects of pitch, lateralization, distortion, density and dynamic accent. Therefore, each combination of movement components is matched to particular changes in the different

sound aspects, which creates a correspondence between movement and sound made possible by the "direct mapping module" (MIROR_D4.3.2, p. 9). Hence, with every variation in movement introduced by the child, a consistent variation in sound is produced. Table 4 and figure 3 illustrate all the movement possibilities and their resulting variation in the different musical aspects and their respective musical features or values. The designers describe each aspect as made up of two bipolar values or features that are mutually exclusive (Table 4). These values, made visible through variation, enable children to experience contrast, and therefore make it possible for children to become aware and discern each feature by comparing it to its' opposing feature.

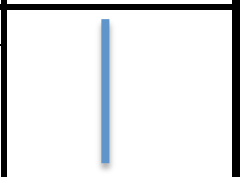
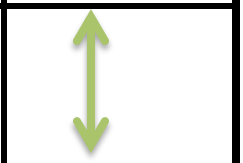
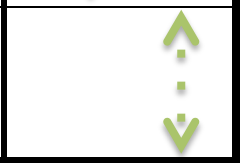
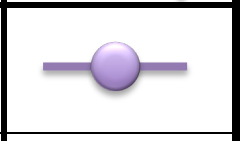
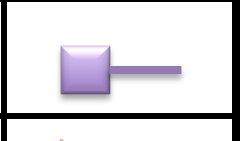
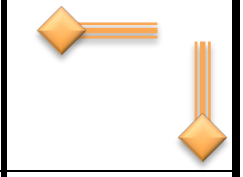
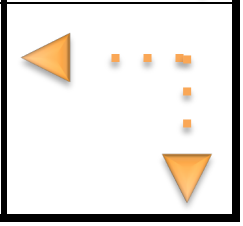
Variation in Gesture	**Music/ Sound Aspects Activated**	**Variation in Sound: Values along the Dimension of Variation**	**Figure 3 Key**
Vertical movement: Hands up	Pitch	High pitch	
Vertical movement: Hands down		Low pitch	
Horizontal movement: Hands left	Lateralization	Left direction (left speaker activated)	
Horizontal movement: Hands right		Right direction (right speaker activated)	
Sharp bouncing gesture vertical movement with hands	Dynamic Accent	Percussive attack	
Smooth gesture vertical movement with hands		Slow attack	
Compression: hands compressed against each other in the middle in front of child	Density	Low density (Single sound)	
Stretch: hands open horizontally at child's sides		High density (Increase in number of sounds)	
Strong and effortful horizontal hand compression and stretch; effortful vertical compression towards ground	Distortion	Strong Distortion	
Smooth and effortless horizontal hand compression and stretch: effortless vertical compression towards ground		Original Sound: No Distortion	

Table 4. BG's Movement Affordances, Corresponding Features of Sound, Sound Variation and Figure 3 Key

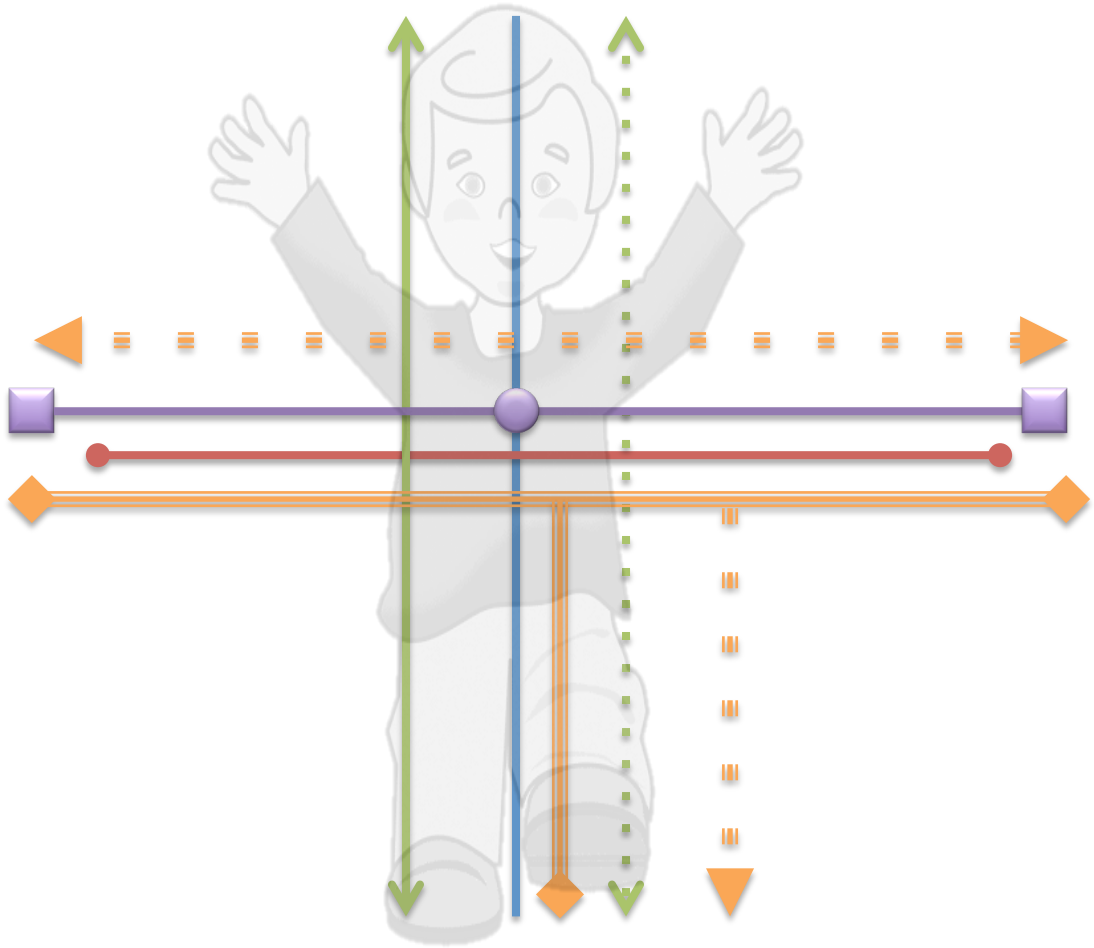


Figure 3. Hand Movement Affordances and Corresponding Aspects of Sound

All the features within the aspects of pitch, lateralization, density and dynamic accent are described as contrasting with the original sound heard. Distortion is describes as distinct from the others, since it comprises of the feature of strong distortion and the absence of this feature characterized by the original sound (figure 4). Therefore, it becomes of interest to investigate how the different variation introduced to the musical aspects affects the participants' possibilities of learning these intended specific aspects.

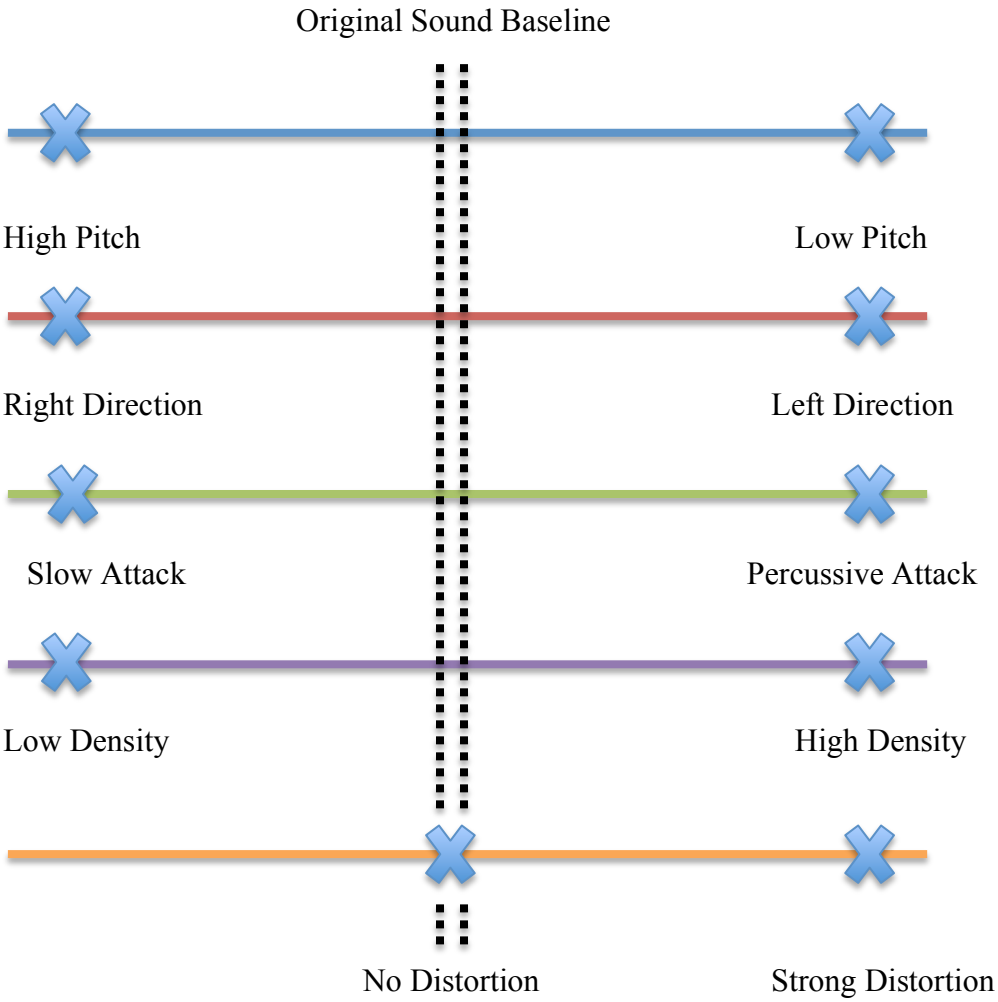


Figure 4. Values of the sound features of pitch, lateralization, dynamic accent, density and distortion plotted against the original sound baseline

Apart from describing the critical aspects as the content of learning, the designers also suggest the manner in which the variation in these aspects should be introduced. These instructions are gathered in the user protocol (MIROR_D.4.3.2) and concern how the children should use the technology. Firstly, the children are instructed to listen to three sounds that belong to a specific group, known as a sound set, for they all share some similar characteristic (table 5). The melodic sound set encompasses sounds that are usually used to create a melody, whilst the naturalistic sound set encloses sounds that are associated with nature and the elements of fire and water. The last experimental sound set covers sounds created by the participants or sounds found in our everyday life.

3 Sound Sets	3 Sounds per set
A. Melodic Sounds	Girl's singing voice
	Guitar
	Clarinet
B. Naturalistic Sounds	Water
	Sea
	Fire
C. Experimental Sounds	Cricket
	Telephone
	Voice Recording

Table 5. Different Sounds Available for the Children to Explore

After listening to the three sounds belonging to one set the children are instructed to choose a sound from the three sounds heard and wear the cylinder that represents the chosen sound around their wrist (Figure 5).

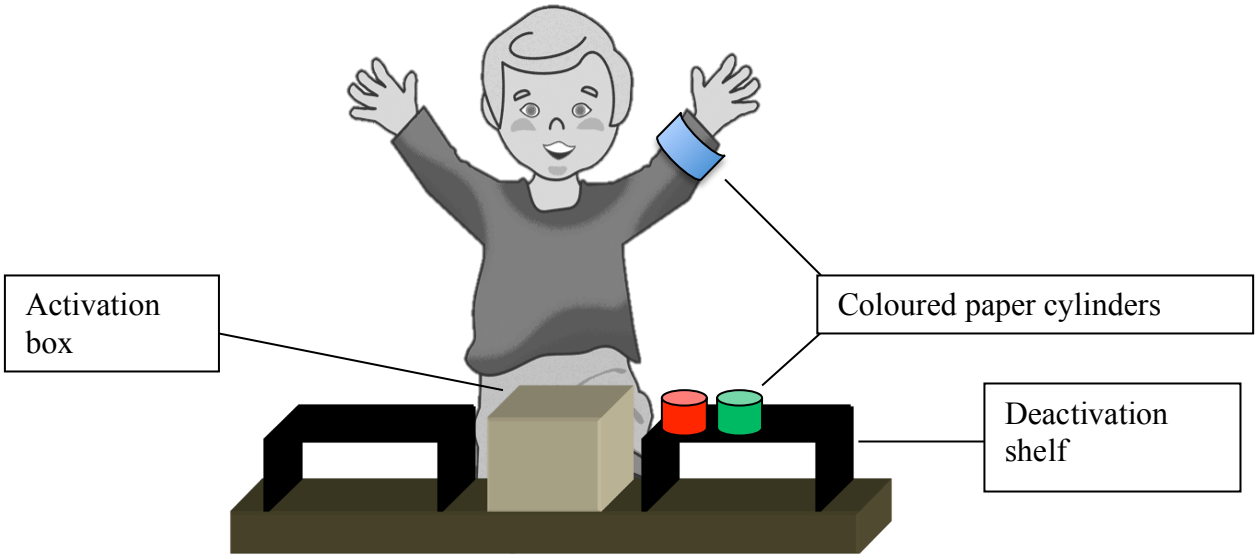


Figure 5. Body Gesture: The Potter external tools

The children are then encouraged to move their hands and thus activate variations in the musical aspects. Therefore, in this instance the sound is kept invariant whilst the different aspects and their features vary. They are also informed that they can stop this exploration of the sound at anytime, by placing the cylinder on the activation box and then moving it on either of the deactivation shelves. The children are encouraged to repeat the same process with the other two sounds. The completion of one sound set is an indication of the completion of one session. The children are then instructed to repeat this procedure with the remaining sound sets.

This suggested protocol creates the possibility for the children to initially experience the pattern of contrast between the different kinds of sounds within one sound set. Variation theory describes this pattern of variation as separation, since the type of sound is the only variation that is activated whilst the critical aspects of pitch, lateralization, density, distortion and dynamic accent remain invariant and invisible. When the child chooses a sound, they have the possibility to experience the pattern of variation of contrast between the different critical aspects and their different features. The designers explain that this pattern of contrast can be experienced differently depending on the pedagogical approach that the technology is set to operate. A linear approach, which is similar to the pattern of variation of separation, would entail that only one aspect (pitch) will vary whilst the other aspects (lateralization, density, distortion and dynamic accent) are kept invariant. Hence, only the contrast between the features of high and low pitch is possible to discern. This will result in diachronic simultaneity, as when the children experience high pitch they will also have to recall previous instances of low pitch (Marton & Tsui, 2004). On the other hand, reticular approach, which is similar to the pattern of variation of fusion, entails contrast between the different aspects and their different features. This will result in synchronic simultaneity and will require the child to experience "different co-existing aspects of the same thing (varying) at the same time" (ibid., p. 18).

Similarly to Variation theory, the developers describe the reticular approach as a more complex way of experiencing than the linear approach. Marton and Tsui (2004) also state that this way of experiencing will lead to a more complex way of seeing the world, or in this case the specific aspect. However, contrary to Variation theory, the designers do not recommend that the linear approach must be experienced before the reticular approach. Any order in these approaches is described as depending on the teachers' objectives rather then, as Variation theorists put it, as a necessary condition of learning (ibid.). Therefore, it becomes interesting to investigate how each approach and their order might influence the possibilities of learning.

When the children move on to experiencing sounds in different sound sets, the pattern of variation of generalization is possibly experienced. Here, the children experience different "appearances" (Marton & Tsui, 2004, p. 16) of the critical aspects and their respective features across different sounds. In accordance to Marton and Tsui (2004) the designers describe this as a way of providing different examples. These examples have the potential to contribute to the full understanding of the specific aspect of the object of learning.

The specific and general aspect.

In this last section I will conclude by briefly summarizing the specific and general aspect of the intended object of learning and also demonstrating how these two are interlinked together. The possible implications for learning will also be highlighted, with indications of what becomes interesting to investigate in both the enacted and the lived object of learning.

When analyzing BG's intended object of learning, variation seems to be identified as the most important act of learning that stimulates the children's awareness towards sound and creates the possibilities for discerning the aspects of pitch, lateralization, distortion, dynamic accent and density. If discernment is successful, this variation might contribute to the children's development of a more powerful way of seeing, or rather hearing sounds (Wallerstedt, 2010). Therefore, it becomes important to investigate if the variation presented in the learning situation makes it possible for the participants to become aware and discern the intended critical aspects.

The function of variation in BG is different from the proposed purpose of variation in other IRMS but similar to Variation theory. This is so because it is described as a tool to make what is critical to learn visible rather then only a tool to introduce imperfections to the technology's imitation of the child's input. Another difference between the principles governing BG and the other IRMS is the functions of repetition and mirroring. Discussion about their function in relation to BG is scarce and we can only speculate that mirroring is used by the technology to mirror the movements of the children and thus create correspondence between sound and movement, whilst repetition is used to create predictability in the sound variation produced. However, it also becomes interesting to see how these two acts of learning emerge in the learning situation and if they affect the possibility to discern the specific aspect.

The structure of the patterns of variation promoted in BG is also different from the structure promoted by Variation Theory. As suggested by Marton and Tsui (2004) separation must be experienced before fusion in order to foster a more effective way of discerning. These patterns should be followed by the pattern of generalization to generalize the variation in the critical aspects to different sounds (Lo, 2012). This is contrary to the designers' belief that both the liner and reticular approaches are conducive to learning no matter their order. Due to the general aspect of exploration, this order becomes susceptible to children's manipulation as they can change the order of these patterns of variation. According to Lo (ibid.) this might decrease the possibilities of discerning the specific aspects. Thus, it becomes interesting to investigate how the uncontrolled organization of the patterns of variation introduced by the encouraged exploration approach impacts the possibilities of learning in the learning situation.

Throughout the designers' description of the general aspect it became evident that this aspect is given greater priority and is imposed on the specific aspect. This is apparent in the discussion of exploration as the principal method established for all the different IRMS, even though all three technologies belonging to this group address different specific aspects. This importance to the method of exploration is also demonstrated in the designers' description of BG as an explorative activity. They also encourage discovery learning through refraining from setting aims and goals whilst limiting interferences from adults. This is strikingly different from Variation theory perspective, since the specific aspect is essential in finding "effective ways of arranging for learning" (Marton & Tsui, 2004, p. 3). Marton and Tsui (ibid.) argue that there is no one successful method for all kinds of learning and thus educators need to arrange the conditions of learning to cater for each individual specific aspect of the intended object of learning. This notion is not reflected in the developers' thoughts about IRMS and BG as the methods of learning of exploration, imitation, interaction, repetition and variation are given a greater priority over the content of learning being taught. These conditions of learning will consequently influence what "is possible….to come to the fore of the learners' awareness" (Marton & Tsui, ibid., p. 4). Therefore, it becomes interesting to investigate the possible impact of giving primacy to the general aspect rather then tailoring it to the specific aspect, on the possibilities of learning.

Section 2: The Enacted Object of Learning

As Marton and Tsui (2004) clearly describe, the enacted object of learning entails the researcher's description of "whether, to what extent, and in what forms the necessary conditions of a particular object of learning appear in a certain setting" (p. 5). Therefore, in this section I will be presenting my perspective, as the researcher, of the unfolding object of learning throughout the BG's learning situation. Through analysing the video recorded data, I will illustrate the space of learning (Marton & Tsui, 2004) created by BG and discuss its possible effects on the participants' discernment.

Variation Theory will be used as an analytical tool "to investigate the significance of variation for possibilities of learning" (Runesson, 2006, p. 407). Even though I will be evaluating the space of learning in its entirety, special focus will be given to the patterns of variation used, the musical aspects and their respective dimension of variation and the organization of these patterns within this space of learning. Nonetheless, other acts of learning present in this space of learning, such as exploration, repetition and mirroring, will be discussed and examined in terms of the possibilities of learning they generate. These learning possibilities will be discussed alongside the specific and the general aspect of the intended object of learning to investigate if they assist the participants to develop the expected capabilities of acquiring awareness of the intended critical aspects of pitch, lateralization, density, distortion and dynamic accent. I will also examine if the technology enables the participants to develop the capabilities of expressing themselves through sounds, building musical structures and problem solving. What must be kept in mind is that this discussion is strictly of a theoretical kind as both the intended and the enacted object of learning are in themselves empirical constructs since no teacher was involved in the planning or implementation of this learning situation. Also the discussed effects of these patterns of variation on the participants' learning are strictly theoretical and must be compared to the learner's perspective to evaluate the impact of these possibilities on their discernment. This will be tackled in the following lived-object-of-learning-section. Furthermore, I shall refrain from phrasing the musical aspects as critical as these aspects are only critical to the educators/designers and may not be critical or visible to the participants.

The themes discussed in this section include an Introduction to the learning situation with The Potter, The Initial Pattern of Variation: Separation or Immediate Fusion and Dimensions of Variation in Musical Aspects. This will be followed by the pattern of variation of Fusion and Generalization of the Musical Aspects were the impact of experiencing co-existing varying aspects and of exploring different sounds on the possibilities of learning will be discussed.

Introduction to the learning situation with The Potter.

The arranged learning situation involving The Potter had the duration of an hour and 30 minutes. As shown in table 6 the children's participation was characterised by short interactions that were either terminated by the participants themselves or abruptly halted by the technology due to errors. The time demonstrated in the below table includes instances when the participants selected a cylinder and explored its sound by introducing movement. In total the participants explored the cylinders for 22 minutes with the rest of the time (1hours 8

minutes) occupied by the designers who had to reset the technology after each participant's interaction and when the technology experienced an error.

Participants	Number of sound sets	Time in total
Victoria	3	2 minutes 22 seconds
Noel	3	5 minutes 38 seconds
Robert	2	3 minutes 33 seconds
Maria	2	3 minutes 11 seconds
John	2	3 minutes 33 seconds
Emilia	2	3 minutes 43 seconds
		22 minutes

Table 6. The Number of Sound Sets, Time Dedicated to Exploration Per Child and Total Time of Interaction with the Technology

The children were observed as moving in a way that resembled the movement shown in the demonstration given by the researchers before they interacted with the technology. This was characterized by moving both their hands vertically and horizontally, swinging their hands from side to side and in a circular fashion. These movement patterns were recurring from session to session and there were only rare episodes where different movements were visible, where one of the participants experimented with wave-like movements with her hands. The short duration of the interaction might demonstrate that the children were not engaged by this technology. From the researcher's perspective the technology did not seem to reassure the participants' confident or trigger enjoyment. A possible reason for this disengagement could be the difficulties and errors the technology seemed to introduce, leaving the children perplexed about what to expect. The participants were also sometimes waiting a while for the technology to reset before each session, only to be disrupted by an error half way through. Therefore, it becomes immediately evident that the technology's performance presents an obstacle to the analysis, as it restricts the actual data that can be analysed by reducing it to 22 minutes. This limits my attempt to investigate what the technology enables the children to do. With this limitation in mind, which will be brought forward in the discussion, I will now attempt to highlight any possibilities of learning within this limited data.

Theme 1: the initial pattern of separation or immediate fusion.

As discussed in the previous section on intended object of learning, the technology provides three different sound sets each made up of three different sounds that share the same characteristics (table 3). The melodic sound set encompassed sounds that are usually used to create a melody, whilst the naturalistic sound set included sounds that are associated with nature and the elements of fire and water. The experimental sound set covered sounds created by the participants or sounds found in our everyday life. In the participants' first session the technicians and researchers chose to activate the melodic sound set. In the second sessions the sound set was changed to either the naturalistic or the experimental sound set depending on the participants' willingness to partake in creating their own sound through the experimental sound set. As shown in table 7, four participants decided to create their own sound whilst the other 2 declined and went on to explore the naturalistic sound set. Due to time constraints only two participants had the chance to participate in a third session were they explored the remaining sound set.

In each session the participants could listen to the three sounds of the selected sound set by selecting one coloured cylinder and moving it on the activation box. Each cylinder represented one sound from the sound sets and when placed on the activation box it would activate a sample of the sound for a short while (3 seconds). The participants were encouraged to listen to all the cylinders before picking the sound they would like to explore. The exploration of sound was possible through selecting a coloured cylinder and wearing it around their wrist and moving their arms around in the working area (Figure 5).

3 Sound Sets	**3 Sounds per set**	**Number of participants**
Melodic Sounds	Girl's singing voice	6
	Guitar	
	Clarinet	
Naturalistic Sounds	Water	4
	Sea	
	Fire	
Experimental Sounds	Cricket	4
	Telephone	
	Voice Recording	

Table 7. Different Sound Sets and Sounds Available for the Children to Explore

When observing the video recorded data of the participants initiating their sessions, two distinct organizations of the patterns of variation were apparent. In 6 out of a total of 14 sessions the participants were observed as listening to the three different sounds pertaining to the selected sound set in succession. In excerpt 1 Robert listened to the guitar, girl's singing voice and clarinet sound consecutively.

Excerpt 1

Melodic Sound Set	
Session 7: Robert p. 10	
Movement	**Sound**
Video 1: 57:35 - Selects yellow cylinder placed it on activation box (AB)	Guitar sound heard
Moves yellow cylinder back to deactivation shelves (DS)	
Video 1: 58:06 - Red cylinder selected on AB	No sound
Video 2: 00:00 - Moves red cylinder back to DS	
Red cylinder selected on AB	Girl's singing voice heard
Moves red cylinder back to DS	
Blue cylinder on AB	Clarinet sound heard
Video 2: 00:24 - Moves blue cylinder back to DS	

Invariant	Varied	Features possible to discern
Sound set	3 different sounds pertaining to the sound set	Pattern of variation makes it possible to discern contrast between the 3 different sounds

Table 8. Space of Learning A in Excerpt 1

As illustrated in table 8, the technology enabled Robert to experience a pattern of variation that might have made it possible for him to become aware of the difference between the three sounds heard within one sound set. By placing the yellow cylinder on the activation box the participant listened to the guitar sound in its neutral, non-manipulated form. This was repeated with the red and blue cylinder. Since the participant experienced variation and contrast between the different types of sounds, he could have possibly experienced the pattern of variation of separation, since all the other musical aspects were invariant (Marton & Tsui, 2004).

This separation was followed by the pattern of variation of fusion as Robert selected an individual cylinder representing a sound, and wore it around his wrist (excerpt 2). This allowed him to move his hands and consequently with every variation in his movement create a variation in the musical aspects within the sound.

Excerpt 2

Melodic Sound Set	
Session 7: Robert p. 10 - 12	
Movement	**Sound**
00:25 – Selects blue cylinder on AB	Original clarinet sound
Wears blue cylinder around his wrist	
Moves his hands down	A slight change to a lower pitch detected
01:52 – Selects yellow cylinder on AB	Original guitar sound
Wears yellow cylinder around wrist	
Hands together moving downwards	Low pitch
02:58 - Selects red cylinder on AB	
Wears red cylinder	
Hands moving downwards	Low pitch

In the space of learning B, different aspects are varying simultaneously, where the technology enabled Robert to possibly discern contrast between the different musical aspects of pitch, distortion and dynamic accent and their respective features. Thus, this variation makes it possible for fusion to occur (Marton & Tsui, 2004). After exploring one sound the participant moves on to the other two sounds respectively (excerpt 2). Excerpt 1 followed by excerpt 2 represents the organization of the patterns of variation occurring in six of the 14 sessions, characterised by the initial experience of separation followed by fusion.

	Invariant	Varied	Features possible to discern
	Sound set	Different sound features	Pattern of variation makes it possible to discern contrast between the different features of the different music aspects, between the different musical aspects and between the 3 different sounds in one sound set.
Invariant		Sound I	
	Sound set	Different sound features	
Invariant		Sound II	
	Sound set	Different sound features	
Invariant		Sound III	

Table 9. Space of Learning B in Excerpt 2

Contrary to these six sessions, in eight out of 14 sessions participants were observed as immediately activating the pattern of fusion. Four of the participants experienced sessions characterised by both initial separation followed by immediate fusion whilst the remaining two participants only experienced immediate fusion across all their sessions. As illustrated in excerpt 3 some of the participants listened to one sound belonging to the sound set and immediately explored it by wearing it around their wrist. This sequence was continued throughout the session as seen in excerpt 3.

Excerpt 3

Melodic Sound Set	
Session 11: John p. 20 -21	
Movement	**Sound**
26:44 – Selects yellow cylinder	Guitar sound heard
Wears cylinder. Starts from the middles and moves his hand down	Lower Pitch
…	…
27:50 – Takes red cylinder	Girl's singing voice heard
Wears cylinder. Lifts hands up	Higher Pitch
…	…
28:25 – Takes blue cylinder to the AB	Clarinet sound heard
Wears cylinder. Moves both hands up	No sound response
…	…

When comparing the two different participatory styles, a disparity in the sequence of patterns of variation is evident. The sequence of separation followed by fusion is a result of the instructions given to the participants during the arranged learning situation demonstration, who were encouraged to first listen to all cylinders and then choose one sound to explore. This sequence is in line with Marton and Tsui's (2004) advice who suggest that "separating the aspects first and then fusing them together is more efficient" (p. 17) in order to discern the different aspects as distinctive. However, due to the explorative approach also encouraged within the arranged learning situation, the children were free to improvise and were not redirected towards the instructed sequence.

When looking at the impact this immediate separation might have on the possibility of learning it became evident that the particular discernment it enables is different from what is intended. This separation opened up a dimension of variation of different sounds within which the guitar, girl's singing and clarinet became values. Through the function of contrast it is possible for the guitar and the other sounds to be experienced as different kinds of sounds. Hence, how can this separation contribute to the learning of the specific aspect (pitch, lateralization, density, distortion and dynamic accent) of the intended object of learning? This separation serves the purpose of making it possible for the participants to become aware of the context of sound (Lo, 2012). This discernment of the context is essential as "One cannot learn mere details without having an idea of what they are details of." (Marton & Booth, 1997, p. 139). This context also exudes meaning (Lo, 2012), as a guitar discerned in a context of instruments would have different meaning from the discernment of the same guitar sound within a context of different kinds of sounds. Consequently each context will have distinct features, as the context of instruments would entail features corresponding to the wood, shape and strings making up the guitar, whilst the context of sounds would entail features correspond to the characteristics of the sound itself. Therefore, by experiencing this separation between the three sounds within one sound set, the technology enables the participants to possibly discern the context of sound and to discern the different sound aspects as belonging to this context. However, due to people's qualitatively distinct ways of experiencing, even separation does not guarantee that the participants will inevitably discern the same intended context or meaning. Nonetheless, the possibility of this happening becomes more probable (Marton & Tsui, 2004; Lo, 2012).

In conclusion, the greater frequency of the immediate fusion compared to separation might hinder the possibility of discerning the contrast between the different kinds of sound and thus discerning the context of sound. This might have a negative ripple effect on the further discernment of the musical aspects. It seems as though the organization of the arranged learning situation that encouraged both a sequential or explorative participation approach restricted the development of an intended common context of sound.

Theme 2: dimensions of variation in musical aspects.

Invariant	Invariant	Varied	Features possible to discern
Sound set	Sound	Different sound features	Pattern of variation makes it possible to discern contrast between the different values of the different musical aspects

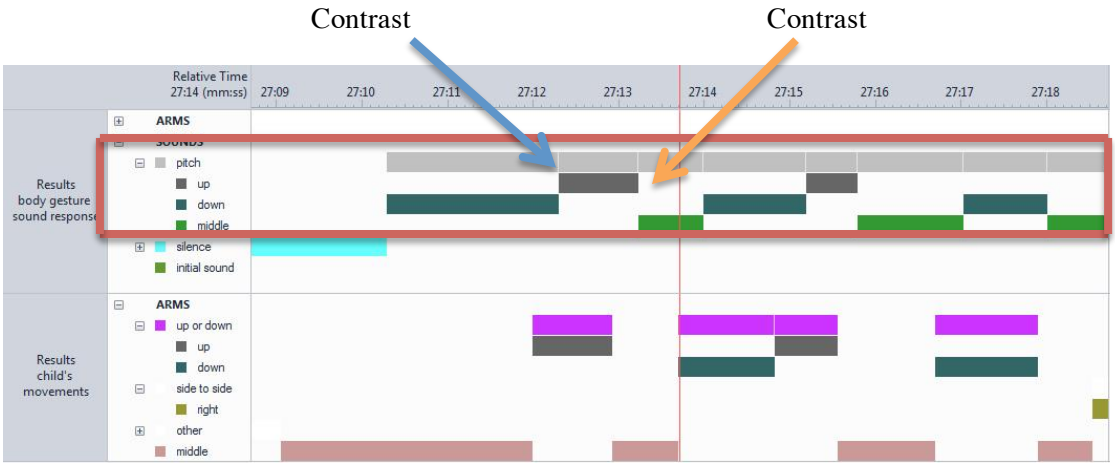
Table 10. Space of Learning

The pattern of variation observed in space of learning C will illuminate both the dimensions of variation opened up in the musical aspects, and the values within these dimensions, referred to as the musical features (Lo, 2012). These patterns of variation will be discussed to illuminate the possibilities of learning they bring about and how these possibilities might assist or hinder participants in discerning the specific aspects of pitch, lateralization, density, distortion and dynamic accent. It is also important to note that these musical aspects and features are "empirically determined" (Lo, 2012, p. 73) since they "only emerge when the students interact with the object of learning during the lesson," (Lo, 2012, p. 78) in this case during the learning situation. They will be later compared to the participants' own experiences to investigate what was possibly discerned. The linguistic terms ascribed to each musical aspect and features are the results of the previous primary document analysis where the

intended specific aspect was investigated. Therefore, these linguistic terms are used for descriptive purposes and not necessarily evident to or understood by the participants.

Excerpt 4

	Sound: Guitar	
	Session 11: John p. 20	
	Gesture	**Movement**
1	27:14 - Raises hands together and pauses his hands over his head	Clear High pitch
2	Hands go through the middle	Pitch lowers and sound returns to its original state
3	Hands down	Low pitch
4	Takes his hands up in a fast way	High pitch
5	Takes his hands through the middle	Pitch getting lower
6	Takes his hands down	Low pitch
7	27:22 - Takes his hands to the side and in the middle	Pitch becomes higher from the previous movement, sound returning to original sound



Visualization 1. Excerpt 4

Excerpt 4 demonstrates the activation of the musical aspect of pitch varying with two values making up its dimension of variation (visualization 1 red box). As shown in visualization 1, John's vertical upward movements were followed by high pitch whilst his vertical downward movement activated the value of low pitch. Contrast was introduced by BG to make it possible for the participants to become aware of these musical features, both contrasting with each other when heard consecutively (turn 3 – 4; visualization 1 blue) and each contrasting with the original guitar sound (turn 1-2, 6-7; visualization 1 orange). This pattern of variation reflects Marton and Booth's (1997) description of discernment, as in order to experience an aspect in a specific manner, one must discern its features from the context, discern its parts, their relationship to one another and their relationship to the whole. Therefore, as shown excerpt 4, variation initiated by BG creates the opportunity to become aware of both the relationship between high pitch and low pitch and their individual respective relationship with the original guitar sound (figure 6). This opportunity makes it possible for the participant to discern pitch.

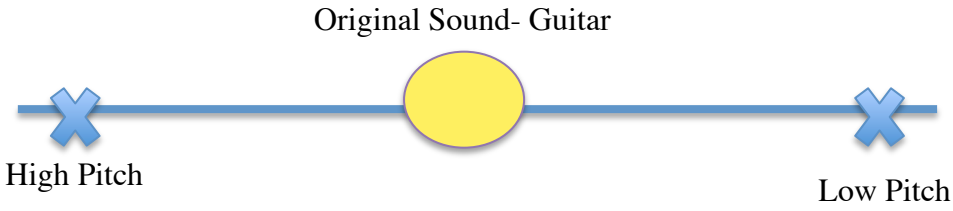
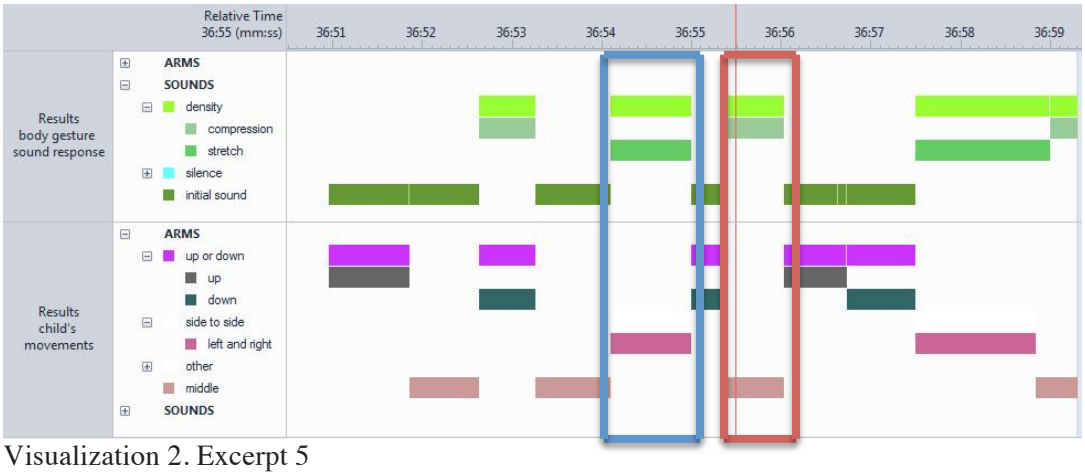


Figure 6. Pitch features, original sound positioned along the dimension of variation of pitch (blue line)

Excerpt 5

	Sound: Water	
	Session 3: Victoria p. 2	
	Gesture	**Movement**
1	36:52 - Both hands in the middle moving down	Sound is rushing water and a droplet of water simultaneously heard
2	Opens hands to opposite sides in the middle	High density heard, the intensity of the rushing water increases
3	Hands together in the middle	Rushing water sound goes back to its original sound and the droplet is also heard at the same time
4	Moves hands up and down	Droplet sound heard on its own and changes to the original sound of rushing water
5	Opens hands to opposite sides at the middle	High density heard, the intensity of the rushing water increases
6	36:59 - Takes hand together in the middle	Rushing water sound goes back to its original sound and the droplet is also heard at the same time



Visualization 2. Excerpt 5

Excerpt 5 demonstrates the activation of the musical aspect of density with two different features making up its dimension of variation. In this excerpt the researcher interpreted the original sound as water rushing down a stream. When Victoria's hands were in the middle, and the cylinder was positioned at waist level, a droplet was heard representing low density

(turn 1, 3, 6; visualization 2 red box) whilst when her hands were at her sides, positioning the cylinder away from her body at shoulder level, an increase in volume of the water was heard representing high density (turn 2, 5; visualization 2 blue box). This variation introduced by BG could make it possible for the participants to become aware of the contrast between the features of high density and the original water sound (turn 1 - 2, 4 - 5) and thus making this feature possible to discern. However, the contrast BG created between low density and the original sound was slightly different, as both sounds seemed to occur simultaneously (turn 3; figure 7). This might hinder the participant from discerning "the limits that distinguish it (low density) from what surrounds it (original sound)" (Marton & Booth, 1997, p. 86), which hinders its discernment.

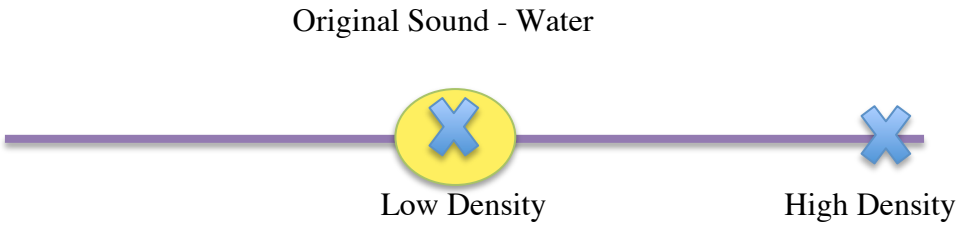


Figure 7. Density features + original sound positioned along the dimension of variation of density (purple line)

Excerpt 6

	Sound: Girl's singing	
	Session 1: Victoria p. 1	
	Gesture	**Movement**
1	29:06 - Moves her both hands up	High pitch
2	And down	Low pitch
3	To the middle and opens hand to opposite sides	High density, its seems like her voice is duplicated, increase in volume
4	Moves hand down from her sides and places them together	Sound goes back to the original sound and then lowers in pitch
5	Moves them together in an upward manner	High pitch
6	Opens hands and moves them shoulder level to the opposite sides	High density
7	29:18 - Closes hands together in the middle and down	Density becomes neutral and the sound becomes lower in pitch

This enmeshment of the low-density and the original sound is evident more than once. In excerpt 6, a different dimension of variation of density was heard, where the original sound had an inherent low-density characteristic where only one girl could be heard singing whilst high density was characterised by the doubling of the girl's voice (turn 4; visualization 3 red box). The lack of contrast between the original sound and low-density (figure 8) made this musical feature harder to discern, since a feature needs to vary in order for us to become aware of it (Marton & Tsui, 2004). This inconsistency and lack of clarity of contrast hinders the possibility of discerning one feature of the aspect of density.

Visualization 3. Excerpt 6

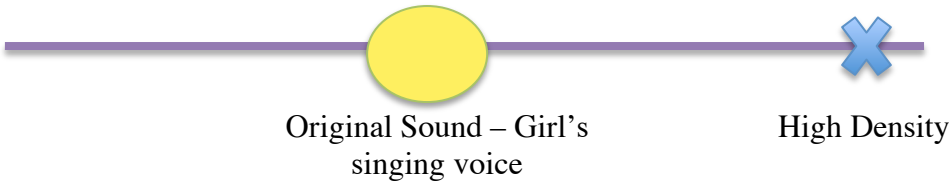
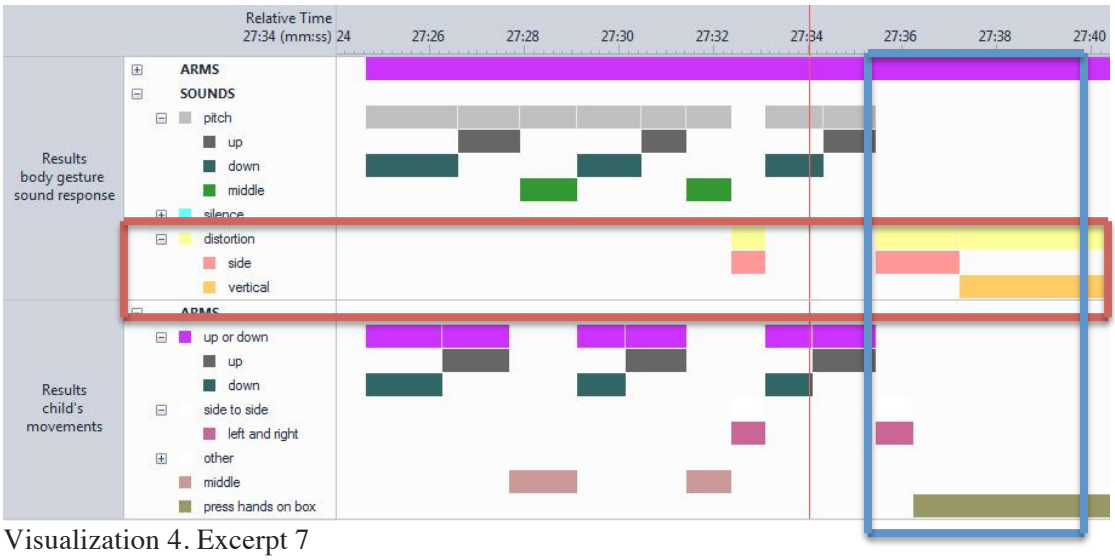


Figure 8. High density feature + original sound positioned along the dimension of variation of density (purple line)

Excerpt 7

	Sound: Guitar	
	Session 2: John p.	
	Gesture	**Movement**
1	27:26 - Lift his hands together up	High pitch
2	Moves his hands together down	Low pitch
3	Moves his hands together up	High pitch
4	Moves his hands together to the middle	Pitch lowers and sound changes to original sound
5	Opens hands to opposite sides	Slight distortion
6	Moves his hands down through his sides	Low pitch/ distortion stops
7	Moves hands together from down to up	High pitch
8	Opens hands and moves them through his opposite sides through middle and down	Distortion/ low pitch
9	27:39 - Compresses hand against work area	Distortion/ sound stops



Visualization 4. Excerpt 7

Similarly, the aspect of distortion presented by BG only enabled the participants to possibly discern one feature making up its dimension (figure 9; visualization 4 red box). In excerpt 7 John has the possibility to experience the musical feature of strong distortion (turns 4 - 5, 8, 9). The pattern of variation of contrast creates the possibility for John to discern the relationship between strong distortion from its surrounding guitar sound. Similarly to low-density, the feature of no distortion was already characterized by the original sound. Therefore, the lack of contrast between this feature and the original sound might hinder the visibility of this feature. What is unique to this aspect of distortion is that two movements activate the same feature of strong distortion (visualization 4 blue box). In turns 5 and 8 John activates strong distortion by opening his hands away from his body at shoulder level whilst in turn 9 he activates the same feature by compressing the cylinder against the activation box. This activation of strong distortion by means of distinct movement might hinder the possibility of discerning this same variation in sound as belonging to the same feature of strong distortion.

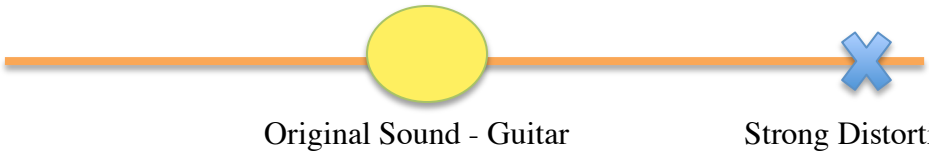
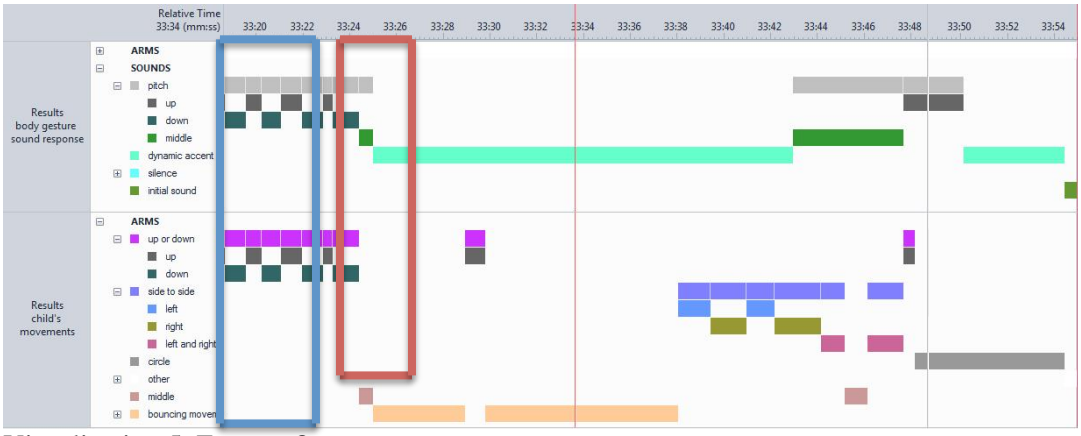


Figure 9. Distortion feature + original sound positioned along the dimension of variation of distortion (orange line)

Excerpt 8

	Sound: Guitar	
	Session 2: Noel	
	Gesture	**Movement**
1	33:17 - Moves both hands up and down 5 times consecutively	High pitch/ low pitch response 5 times
2	Hands in the middle and moving as if he was bouncing a ball forcefully up and down and keeping his hand in the middle at the same time	The impact of the change in pitch becomes powerful and sharp as it changes from high pitch to low pitch (percussive attack). This change also becomes faster.

3	Moves his hands up and down trying to catch up with the sound	The sound seems like it bouncing from high pitch to low pitch on its own. A gradual slowing down of the tempo is heard whilst the powerful impact becomes smoother (slow attack), however not in sync with the movement
4	Swings hands from side to side	Sound seems to have returned to its original tempo and smoothness, but still not in sync with movement
5	Moves both hands in a circular fashion creating 2 circle at both sides	Sound changing from high to low pitch similar to dynamic accent but slower, not in sync with movement, movement following sound
6	33:55 - Stops in the middle and takes off cylinder	Sound stops



Visualization 5. Excerpt 8

Another aspect opened up throughout the sessions is the aspect of dynamic accent. This aspect seems to have two features that are identified as slow attack and percussive attack (figure 10).

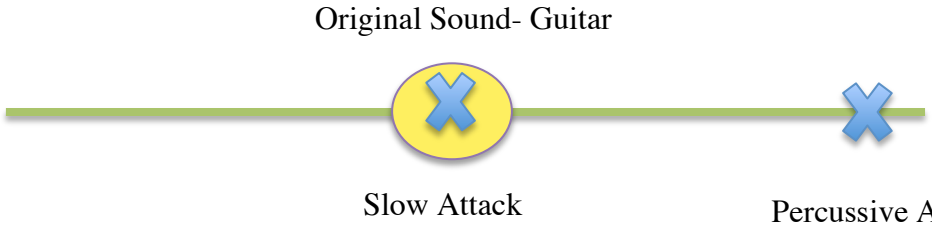


Figure 10. Dynamic accent feature + original sound positioned along the dimension of variation of dynamic accent (green line)

This musical aspect is described as made up of an attack, which is "proportional to the impulse given to the sound object, a percussive sound (percussive attack) being associated to a sharp gesture and a slow attack being associated to a smooth gesture." (MIROR_D4.3.2, p. 12). Therefore, when the participants commits to a sharp effortful vertical movement they will activate a rapid and more powerful impact in the pitch changes (excerpt 8 turn 2; visualization

5 red box). On the other hand, when the vertical gestures are smooth the changes in pitch are also smooth and gradual, which is referred to as slow attack (Excerpt 8, turn 3; visualization 5 blue box). As excerpt 8 demonstrates, when Noel forcefully bounces his hands up and down, whilst keeping his hands at shoulder level, the technology activates the feature of percussive attack causing a sharp change in pitch (visualization 5 red box). This creates the possiblity for the participant to experience contrast between the smooth sound of the original sound and the sharp and powerful change in pitch. This makes this feature visible from its surrounding sound and thus becomes possible to discern. However, the discernment of the feature of slow attack is compromised by its enmeshment with the original sound and pitch changes, as all of these sounds are characterized by smooth sound changes. Therefore, the absence of contrast between the original sound, pitch changes and this musical aspect makes it difficult to discern. Additionally, the gradual change observed as the sound changes from percussive attack to slow attack creates ambiguity over its boundaries as it becomes difficult to discern where this feature starts and ends. Marton and Booth (1997) discuss that in order to experience something we have to discern "the limits that distinguish it from what surrounds it" (p. 86). Therefore, if this condition is absent, such as in excerpt 8 the possibility to discern this slow attack feature is hindered.

Theme 3: fusion and generalization of the musical aspects.

Invariant	Invariant	Varied	Features possible to discern
Sound set	Sound	Different sound features	Pattern of variation makes it possible to discern contrast between the different values of the different musical aspects

Table 11. Space of Learning D

As illustrated in space of learning D, this theme will firstly discuss the co-existing variation occurring in more then one musical aspect simultaneously. The technicians and researchers decided to activate this possibility of fusion throughout all the sessions due to the restricted time of the learning situation, the participants' limited attention span, and the need to evaluate all the possible variation of all the intended critical aspects. Therefore, all these musical aspects were activated in every participant's session.

In excerpts 6 (turns 3, 7) and excerpt 7 (turns 5, 8), the same horizontal movement activated different musical aspects of density (in excerpt 6) and of distortion (in excerpt 7). These musical aspects were also observed as mutually exclusive, as the same movement could activate either distortion or density. This activation was observed as unpredictable and did not follow any evident pattern. This similarity in movements and the mutually exclusive activation seems to hinder the possibility of learning these two aspects as separate, resulting in the enmeshment of these aspects and their respective features. On the other hand, as excerpt 8 (turn 2) and excerpt 4 (turns 3, 4) demonstrate, pitch and dynamic accent are also activated by similar vertical movement. Another similarity concerning these two aspects involves the nature of the sound produced, as both aspects produce variation in the sound's pitch. Whilst the aspect of pitch created variation in high and low pitch, the dynamic accent created variation in the impact of these pitch changes. Unlike density and distortion, these variations occurred simultaneously. This similarity between the activation movements and the

similar nature of variation also hindered the possibility to learn that these two aspects (pitch and dynamic accent) are separate. Therefore, the commonalities between these four musical aspects and the fact that they have not been separated appropriately before being experienced simultaneously hinders the possibility of discerning these aspects as separate (Lo, 2012).

Invariant	Invariant	Varied	Features possible to discern
Sound set	Same changes in sound aspects and features	Sounds	Pattern of variation makes it possible to discern different examples of variation in the same four sound features

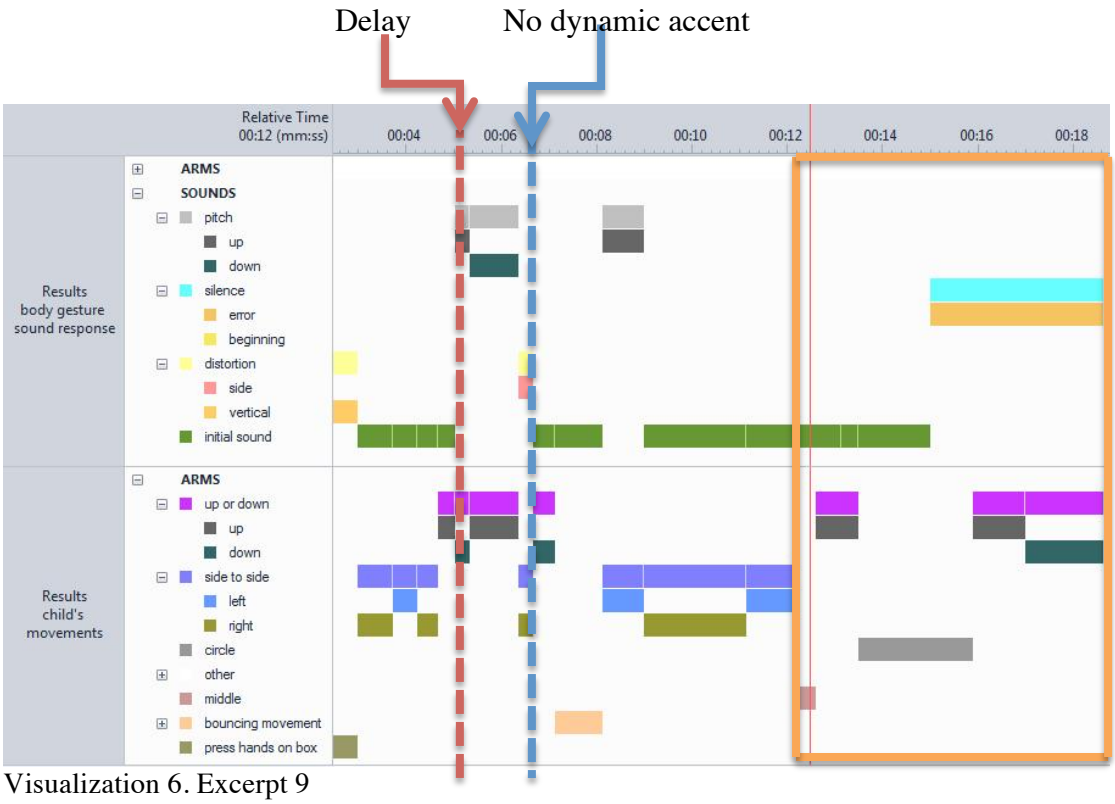
Table 12. Space of Learning E

Space of learning E illustrates the pattern of variation of generalization were the participants experience variation in the same aspects across different sounds (table 12). This allows the participants to experience the possibility to discern the aspects as independent and separate from the one particular sound (Marton & Tsui, 2004; Lo, 2012). However, during the sessions it became evident that the variations in the aspects were not consistent throughout the exploration of the different sounds. Each sound seemed to provide different affordances to the different musical aspects. This counteracted the function of generalization of presenting "varying appearances" (p. 16) of the same aspects in order to come to a powerful way of understanding these aspects (Marton & Tsui, 2004).

Excerpt 9

	Sound: Telephone	
	Session 10: Maria	
	Gesture	**Movement**
1	14:05 - Quickly moves her hands down and compresses her palms against working box	Distortion in sound
2	Quickly lifts the cylinder hand to her right side at shoulder level	Original sound
3	Moves her cylinder hand in a semi circle towards her left side at shoulder level	Original sound
4	Moves this hand quickly from her left and quickly to her right side in a semi circle fashion, straight up above her head	Original sound
5	Hand move down forcefully	High pitch (delayed response of previous movement)
6	Hand moves up forcefully	Low pitch (delayed response of previous movement)
7	Moves hand down through her right side and down to ground	Distortion
8	Forcefully throw her hand up and bounces it down	Original sound
9	Swings her hand from left to right twice whilst bringing her hand behind her whilst swinging	High pitch then sound goes back to original sound
10	Moves her hand to middle and then up	Original sound

11	Moves her hands down	Original sound
12	Move her hand in a full circle x 2	Original sound and the sound stops



Visualization 6. Excerpt 9

Excerpt 9 is representative of most sessions depicting instances that hindered the function of generalization. As illustrated, variation in the aspects was delayed (turns 5, 6; visualization red line), aspects were not activated when their activation movements were performed (turn 8; visualization blue line), and sound responses were not in synchrony with the movements (turns 10 – 13; visualization orange box). This unpredictability of the variation of the aspects is due to the different affordances the different sound sets enabled. This is demonstrated in excerpt 5 and 6 where the aspect of low density is characterized by a drop sound in the naturalistic sound set whilst in the melodic sound the original sound is already characterizing this low density. Thus, these different sound sets allow for different learning possibilities that might result in discerning the same musical aspect or feature in both excerpts as distinct. Therefore, the different sounds and their different affordances to the different musical aspects hinder the pattern of generalization, hindering the possibility of becoming aware that the changes in sound across the different sounds belong to a common musical aspect. This creates the risk that the sound changes are perceived as characteristics of the individual sounds hindering the possibility of discerning the presence of the different musical aspects.

Section 3: The Lived Object of Learning

In this section I will tackle the last two research questions concerning the lived object of learning and what the children as research collaborators contribute to this BG technology. Through analysing the recall semi structured interviews, I will present the participants' experiences of the patterns of variation in the musical aspects and any other factors that might be in the participants' awareness throughout the learning situation with BG. As noted previously in the enacted object of learning, the data collected concerning the learning situation was in itself limited due to the technological errors introduced by BG. This data also demonstrates that the participants had a very limited interaction time with the technology with a total of 22 minutes, which might have restricted the possibility of any discernment and consequently limiting the discovery potential of this study. Moreover, some of the procedures taken up in the arranged learning situation seem to also have influenced and even restricted the participants from obtaining awareness of these possibilities, such as from acquiring an awareness of the context of sound. Nonetheless, I will still attempt to highlight what the participants became aware of during such a restricted time, how and why did they acquire such awareness, if this awareness included any possibilities of learning highlighted in the enacted object of learning, and if it resulted in the intended discernment. This analysis, even though restricted, will generate feedback for the purpose of improving both the BG technology and the arranged learning situation procedures.

As mentioned in the theoretical framework, a way to reveal the lived object of learning is to identify ways in which individuals speak of the object in question and its external and internal horizons. The external horizon will involve a description of what the participants perceive as the context surrounding the learning situation, whilst the internal horizon will include descriptions of the different parts that constitute the object of learning (Lo, 2012). These descriptions will serve to identify the distinct ways the learners experience the object of learning at different instances throughout the learning situation (Marton & Booth, 1997).

The external horizons.

Through asking open-ended questions about the variation in sound, the participants identified and described what is in the fore of their awareness when looking back at a particular variation.

Excerpt 9. Noel
R: What happens here when you lift your arm?
N: The sound changes. For you know, the little Kinect. It kind of saw it a little further up so that there was another sound.
…
N: It is when the Kinect sees that, you see here (pointing to the screen), the yellow (cylinder) has smaller ribbon, the red (cylinder) is middle and the blue (cylinder) is almost covered with tape.
R: But what happened to the sound when you lifted the arm, did you think of that?
N: The Kinect just perceives that it goes up or down.
R: And what does the Kinect do with the sound?
N: It changes it because it perceives it becomes different.

As excerpt 9 demonstrates, Noel perceives technology as the context surrounding this object of learning, as his awareness is focused on the motion sensor input device Kinect, the cylinders and the tape around each cylinder and how these work together to produce variation in sound.

Excerpt 10. John
(Video clip of change in pitch in guitar, as John is moving his arms down and up)
R: What happens there?
J: It's as if you pull down (drar isär) the sound (Illustrates sound change using his voice).
… (Video clip of change in distortion in guitar, as John is compressing hands against workbox)
R: What happened when you press your hands against the plate?
J: Yes I think it is a bit, (mimics the sound), it feels a bit as if you push it a bit.

Alternatively, John seemed to perceive this learning situation as embedded in a context of movements. This external horizon focused his attention on different aspects from what Noel was aware of, such as the gestures. Therefore, the different external horizons are determining what aspects are visible to the participants, which in return influences the meaning given to the object of learning (Lo, 2012). In both these cases, the context of technology and movement allows the participants to discern that the sound is changing. However, the technology and the learning situation does not enable these two participants to discern a context of sound and therefore does not allow for the possibility to discern the changes in sound as part of the intended musical aspects.

In excerpt 11 John describes the activation of the feature of high density as a water horn, which disappears as he moves his hands to the middle. In this instance the variation in sound is explained through transforming the sound into an object, as he perceives the object of learning against a background of familiar objects.

Excerpt 11. John (sea sound)
(Video clip of change in density in sea sound)
R: What happened to the sound when you clapped your hands?
J: (inaudible) the water horn.
R: Precisely, like a water horn.
R: So what happened to the sound now? (His hands are in the middle clasped together)
J: It was, the water horn disappeared.

Even though this objectification of sound does not correspond with the intended context of sound, it demonstrates a certain awareness of contrast between the original sound and the sound changes triggered by high density. By matching the sound to a horn John might have seemed to communicate that the sound is somewhat loud and characterized by high volume, which contrasts to its absence indicating a change in the loudness or volume of the sound. This description provided by John is somewhat similar to excerpt 5 and 6 discussed in the enacted object of learning. It seems like the water horn is analogous to the increase in intensity heard in the rushing water sound (excerpt 5) and the duplication of the girl's singing voice (excerpt 6) brought about by variation in high density. Furthermore, John's description and these excerpts correspond to the designers' description of the musical feature of high density as characterized by an increase in the volume of a sound. Taking in consideration these similarities between the intended, enacted and lived object of learning, can we claim that the technology makes it possible for John to discern the musical aspect of density? Even

though John might have described a sound change triggered by high density, he does not make sense of this variation against a context of sound and thus in relation to this musical aspect but he seems to understanding this contrast against a context of familiar objects. Once again, the technology and the learning arrangement's failure to establish a common context of sound, has enabled the participants discerning other contexts.

Excerpt 12. Victoria (water sound)
(Video clip of change in density in water sound)
R: What's going on with the sound? Let's see if we can rewind a bit. It is a sound that we had from the beginning. (Listening to the drop sound again)
V: (Pause)
R: If you would like to imitate the sound? Could you do it?
V: No. (Pause) Click

Victoria's experience in excerpt 12 seems to complement John's by providing a description of the other value of density. This "click" sound described by Victoria corresponds to the researchers' description of the droplet sound when observing Victoria explore the water sound (excerpt 5). In the enacted object of learning this sound was linked to the musical aspect of low density, as it presents one droplet contrasting to the original sound of rushing water. Yet again, a participant seemed to give a clear description of the sound changes generated by density, which matches with both the enacted and intended object of learning. However, similarly to John, the technology does not enable Victoria to connect her experience of this sound to the musical aspects of low density. Nonetheless, the technology and the variation it produces make these two participants aware of the sound changes and the contrast they create.

Excerpt 13. Robert
(Video clip of clarinet sound, as he moved his hands up and down)
R: What's going on here?
Ro: When you take your arms up it becomes bright, if you take them down, it sounds dark.

Excerpt 14. Noel
R: When you went down with the arm what happens?
N: The sound became longer.
R: And when you say longer, do you mean it became weaker or did it?
N: No it changed from very high to pretty low.

Excerpt 15. Robert
(Video clip of guitar sound, as he moved his hands horizontally)
R: How is it possible to describe?
Ro: When you pulled, it became really dark, when you drew it, it became a little less dark.
R: Aha, there was a difference in darkness there.
(listens to distortion)
R: What about the sound here?
Ro: She sang a little false there.

This awareness of contrast is also observed in other instances where participants explain variation in sound in relation to contrasting metaphors. In excerpt 13 and 14 two participants explain the variation in the aspect of pitch as changing from "bright" to "dark", short to "longer" and "high" to "pretty low". These descriptions might indicate that BG enabled the participants to discern the contrast created by introducing variation in high and low pitch. This contrast is also described when a participant hears variation triggered by distortion

(excerpt 15). It is interesting to note that in excerpt 14 Noel gives a very precise description of the variation in pitch, matching the exact definition given by the designers and researcher in the intended and enacted object of learning (excerpt 4). Furthermore, these contrasting metaphors were mainly used, by the participants to describe the contrast heard between high and low pitch. This might indicate that BG present clearer contrast with regards to the dimension of pitch that allures the participants' attention.

BG and the learning situation's inability to establish a common context of sound resulting in a lack of awareness of the distinct musical aspects is further illustrated by the similarity between the metaphors used to describe the sound variation triggered by the different musical aspects. Noel describes the pitch changes in the sea sound by claiming that "*It sounds like an explosion"*. Emilia uses the metaphor of rain to explain the changes in pitch when exploring the water sound by uttering *"When I move up it starts to pour down"*. All these figures of speech are similar in characteristic to the water horn described by John, all indicating an increase in volume irrespective of the musical aspect heard. This lived experience seems to support the researcher's observations discussed in the enacted object of learning, where the pattern of variation of fusion along with the commonalities between the four musical aspects with regards to activation movement and sound characteristics introduced by BG hinder the possibility of discerning these aspects as separate and distinct (Lo, 2012). In fact, there was little difference between how pitch, distortion and density variation were described amongst the participants. On the other hand, variation in dynamic accent was hardly described apart from when Noel imitated the sound changes with his voice (excerpt 16).

Excerpt 16. Noel
(Video clip of guitar sound, as he was bouncing his hands)
R: And here you seem to bounce a ball, what happens to the sound then?
Ro: It makes like dojn, dojn (imitates with his voice.) Then it becomes such a sound.
R: Yes it does, a dojn sound.

The technology's inability to divert the participants' awareness towards the different musical aspects and its incapability to enable the participants to distinguish between one musical aspect from another makes the possibility for the participants to discern the pattern of generalization far from possible. On a more general level BG enables the participants to discern that the different types of sounds in the sound sets presented different examples of contrasting sound changes. Therefore, the lived object of learning does not only support the enacted object of learning in its claim that generalization is hindered due to the different sound affordances presented by different sounds, but also goes on to suggest that its main obstacle concerns the technology and the learning situation's inability to establish a common context of sound to discern the sound changes against.

What becomes significant to discuss is what enabled these participants to perceive distinct external horizons when faced with similar experiences. From a Variation theory perspective there are three reasons that could contribute to these differences, including the participants previous experiences, the technology's lack of attempt to establish one context and the arranged learning situation's lack of attempt to establish a common relevance structure. Marton and Tsui (2004) argue that the learners' previous experiences influence what aspects are visible in a given learning situations. This is clearly evident in Noel's case (excerpt 1). During the interview Noel mentioned his previous experience with technology that used similar detection sensors as BG. When interacting with BG, Noel seemed to immediately focus on the familiar detection sensor and its function. These discerned aspects seemed to

have become 'sensitized' (Marton & Tsui, 2004, p. 11) as Noel saw this new learning situation of BG in the light of his previous experiences with similar technology (Marton & Tsui, 2004). Like Noel, all the other participants might have their own different experiences that may effect how they see the learning situation (Marton & Tsui, 2004). Therefore, it is expected that each and every participant will perceive different context at different instances in the learning situation resulting in distinct experiences of the learning situation. Additionally, during the learning situation the participants were left free to explore the sounds as they see fit, with no attempt to establish a common context of sound. Consequently, since there was no attempt to take in consideration the participants' previous experiences and no attempt to establish a common context, the possibility of perceiving the same context and hence the same understanding of the intended specific aspects become very slim (Lo, 2012).

Another issue influencing what aspects are visible and what context is discerned involves the 'relevance structure' of the learning situation. All the participants are encouraged to face the interaction with an aim of exploring the technology. This explorative approach is embedded in the general aspect of the intended object of learning, as discovery learning is encouraged whilst adult interventions are discouraged. Therefore, the participants are free to make their own objectives. Marton and Booth (1997) describe these individual objectives as the 'relevance structure' of the learning situation. This structure influences what the learning situation demands from the participants and the behaviour it calls for to fulfil these aims (Marton & Booth, 1997). This freedom in choosing their own relevance structure creates a greater possibility for the participants to miss out on the intended aspects. The participants shifting understanding of the learning situation demonstrate this, as they move from one objective to another, focusing on different aspects at different instances. Therefore, the organization of the learning situation resulted in a sense of aimlessness that continued to decrease the possibility for the participants to discern the intended object of learning.

Language.

Marton and Tsui (2004) argue that language is fundamental to discernment as it "plays a central role in the construal of experience" (p. 25). When children are introduced to a guitar for the first time, adults or educators present the word that represents this instrument. In doing so children are given the possibility to discern the word guitar and its meaning. Pramling and Wallerstedt (2009) refer to these new words as institutional terms that serve the purpose of helping children communicate, enabling them to make finer distinctions between different instruments in the field of music. When learners are then introduced to a mandolin they might confuse this instrument with a guitar because of its similar shape and strings. However, educators can help learners by introducing the institutional term mandolin, which helps them distinguish these two instruments. Therefore, language represents objects, helps learners to distinguish these objects and assists them in discerning the variation between guitar and mandolin (Marton & Tsui, 2004). On the other hand, variation provides an opportunity to experience this distinction in language, as it becomes apparent to the child that not all string instruments are necessarily guitars (Marton & Tsui, 2004).

However, what if the children are not exposed to these institutional terms? Will they be able to discern this new instrument as different from a guitar? These questions are particularly significant to this study since the technology and the learning situation does not impart these linguistic distinctions to the participants that correspond to the intended specific aspects of

pitch, lateralization, density, distortion and dynamic accent. Pramling and Wallerstedt (2009) explain how verbal language "appears to be a kind of meta-language for sense making" (p. 149) helping children "explain, directing awareness, making distinctions, (and) formulate relationships etc." (p. 149). Therefore, it is essential to investigate how the participants communicated and made sense of these variations in sounds despite not being introduced to these linguistic distinctions during the learning situation.

Excerpt 17. Robert
(Video clip of Robert exploring the clarinet sound)
R: What happened to the sound there?
R: It becomes weird.

Excerpt 18. Noel
(Video clip of Noel exploring girl's singing voice as he moves his hands to opposite sides)
R: So how did that sound?
N: The girl who sang again but stranger.

Excerpt 19. Emilia
(Video clip of Emilia exploring guitar sound as she moves her hands up and down)
R: What happened here?
E: I don't know

These three excerpts demonstrate the participants' uncertainty in describing the variation in sound. The use of words such as "weird" and "strange" convey a sense of unfamiliarity. Excerpt 19 reinforces this unfamiliarity, as all of the participants at some point in the interviews cannot find the words to describe what is happening to the sound. This might indicate that these variations in sounds have never been experienced before and thus " the difference were not so critical in relation to the specific context of their everyday lives as to warrant making distinctions by linguistic means" (Marton & Tsui, 2004, p. 28). Furthermore, there was no preparation or pre-test before the learning situation to introduce these unfamiliar linguistic distinctions. This limitation in the organization of the learning situation resulted in the participants' use of their own voice (excerpt 20) or make reference to familiar objects (excerpt 21) to mimic the sound changes heard.

Excerpt 20. Maria
(Video clip of voice recording sound)
R: What happened there?
M: growl (mimics a growl sound)
R: What can you hear?
M: growl (mimics sound with her voice)

Excerpt 21. Maria (guitar sound)
R: When you raise your hands and when you put them down
M: It sounds like an airplane.

Other metaphors used included visual metaphors (excerpt 22) and spatial metaphors (excerpt 23 & 24).

Excerpt 22. Robert
(Video clip of guitar sound, as he opened his hand to opposite sides)
R: How, is it possible to describe?

R: When you pulled, it became really dark, when you drew it, it became a little less dark.

Excerpt 23. Victoria

(Video clip of girl's singing voice, as she moved her hand up and down)
R: First here, you pull your hands up and down. What happens to the sound there? Do you think we should listen again?
V: Mhm
R: (rewinds video clip) Here we can listen to the sound again
V: It became a longer sound
….
R: Well, then, let's see what happens when you pull out your hands to the sides. What happened here?
V: I don't know
R: It might be difficult to describe. We take a look again. How did it sound do you think?
V: A bit shorter

Excerpt 24. Emilia

(Video clip girl's voice)
R: What is happening? Is it possible to hear something?
E: When you brought it up so it became higher.
…
R: When you took your hands down, what happened then?
E: It became lower.

These excerpt are similar to the examples of synaesthesia observed in Pramling and Wallerstedt's (2009) study as in both studies the participants are observed transferring "qualities of one class or modality of sensory- perceptual experience" to another modality (p. 136). The auditory modality is transferred to visual modality as the changes in sound are given colour, varying from dark to light (excerpt 22). Another example illustrated in both excerpt 23 and 24 involve the transfer from auditory modality to spatial modality as Victoria uses words such as longer and short, whilst Emilia uses words such as high and low in an effort to make sense of what is happening in the sound. It is interesting to note that both the spatial and visual metaphors communicate a sense of contrast, as the sound is not solely described as long or dark but as changing from one dimension to another within a spectrum. Thus, once again the technology seems to be enabling the participants to become aware of the contrast between the sound changes, which are heard as opposites. These metaphors are used interchangeably when participants refer to changes in pitch, density and distortion. This reinforces the previous claim that the technology does not enable the participants to discern these sound changes as characteristics of the separate musical aspects. However, the metaphor involving high and low values was only used by one participant to describe variation in pitch. This links to the previous observation claiming that BG presents a clearer contrast with regards to the dimension of pitch that allures this particular participant's attention.

The external horizons and internal horizons.

Table 13 summarises the different external horizons and their respective internal horizons. It is important to note that each way of experiencing is not linked to an individual participant. However, all the participants are observed as shifting from one way of experiencing to another at different instances. Table 13 evidently illustrates that there are different aspects in their awareness helping them make sense of this variation. These vary from seeing the sound

changes as a function of the technology or making sense of the variation by thinking of familiar object with similar sounds.

External Horizon	**Internal Horizon**
Movement	Variation in sound explained due to variation in movement: Pulling, pressing and pushing of the sound
Technology	Variation in sound explained due to the functions of the technology: Kinect, sensors, cylinders, tape covering cylinders
Familiar Objects	Variation in sound explained through the use of familiar objects and similes: Like an/a water horn, robot, mobile phone malfunctioning, airplane, alien, explosion
Contrasting metaphors	Variation in sound explained through the use visual and spatial metaphors: Longer – shorter, bright – dark, darker – less dark

Table 13. The Participants' Distinct Ways of Experiencing the Interaction with BG and the Variations in Sound

When observing the collective external horizons experienced, none of the participants seem aware of the intended context of sound. According to the enacted object of learning, this discernment of the context of sound is possible through experiencing immediate separation. However, the organization of the learning situation did not facilitate this sequence as the participants, in eight out of 14 sessions, initially experienced immediate fusion instead of the pattern of separation. Theoretically, if separation is not experienced, the participants run the risk of not discerning the context of sound and additionally discerning the musical aspects against a different context. As seen in the above results the technology and the learning situation do not enable the participants to discern this context of sound. Consequently, the different context discerned by the participants (table 13) elicited different meanings, which are distinct from the intended object of learning.

This difference between what is intended and what is lived is also evident in the internal horizon, as none of the participants seem to be aware of the intended aspects and features. However, most of the participants describe the sound changes produced by these different musical aspects as contrasting, as they use metaphors, familiar objects and their own voice to communicate these differences in sound. Nonetheless, the learning situation and technology do not enable the participants to discern these contrasts against a context of sound. This results in the participants being unable to link these contrasting changes to the musical aspects. Furthermore, BG and its learning arrangement do not equip the participants with the institutional terms and linguistic distinctions needed for the participants to communicate about these contrasting musical features. In conclusion, this lived object of learning is characterised by a Variation Theory principle stating that at times the intended and enacted object of learning do not always match up to the lived experiences (Marton & Tsui, 2004; Lo, 2012).

Chapter Five: Discussion

In this chapter an overview of the different results will be provided, making connections between the intended, enacted and lived object of learning. A learning gap presented between these objects will be discussed and possible improvements presented. This gap will also be used to establish what possibilities of learning the technology needs to present in order to assist the participants in developing the intended object of learning. Furthermore, the role of both the participants as research collaborators and of Variation Theory as the analytical tool will be discussed. These results provide insight into the possibilities of learning enabled by the technology, whilst also evaluating if these possibilities are similar to the intended object of learning. This contributes to research within the MIROR project, since it provides an evaluation of an under researched IRMS technological platform whilst also dealing with the blind spot in the existing MIROR research by taking in consideration the lived object of learning.

With regards to the study's contribution to the field of technology based learning, the results provide a research instance where technology does not seem to present the learners with a rich environment that motivates the learners to discern professional skills, academic skills or most importantly the learning it intends to impart (Gee, 2003; Linderoth, 2010). This study also demonstrates that this occurrence is not solely a consequence of poor design of technology (Gee, 2003), but that the learning situation the technology is situated in might also present major obstacles and restrict the technology's potential possibilities of learning. Therefore, these results provide important implications in order to move this field of research away from implementing the same technology driven testing protocol, used to test for potential technical errors, from being applied to studies that aim to evaluate and investigate the learning possibilities the technology enables. As evident in this study this testing protocol will limit the study's discovery potential with regards to learning. Nonetheless, the results outlined below will still provide insight into the research questions posed with regards to this study's specific arranged learning situation with BG. Furthermore, limitations with regards to the transferability of this insight will be discussed in the limitation section in the following chapter.

The Intended, Enacted and Lived Objects of Learning

In the intended object of learning the designers' perspectives focused on the acquisition of awareness of sound morphology including the musical aspects of pitch, lateralization, density, distortion and dynamic accent. The awareness of these aspects entails the understanding of their features of high and low pitch, left and right lateralization, high and low density, strong and no distortion and percussive and slow attack (MIROR_D4.3.2). Other capabilities promoted as developing through interacting with BG included problem solving, expressing oneself and constructing through music and movement (MIROR_D4.3.2). The acts of learning promoted to develop these capabilities included variation, repetition and mirroring all within an explorative approach were a lack of a common relevance structure and common objectives were encouraged (MIROR_D4.3.2).

Within Variation Theory perspective, the enacted object of learning is always expected to differ from the intended object of learning due to the unpredictability that learning situations bring along (Lo, 2012). The unpredictability presented by the learning situation in this study

brought about major limitations to the evaluation of the enacted object of learning as well as restricting and hindering the possibilities of learning initiated by BG. There was no attempt to organize a similar interaction experience between the technology and all the participants, as only two children explored all sound sets. There was also a lack of control over the patterns of variation activated, as the participants were encouraged to explore the sound sets as they see fit resulting in some participants experiencing patterns of separation followed by fusion whilst other only experienced fusion. There was also no attempt to establish a common context or common objective to work towards leaving the participants unprepared to venture through this unfamiliar interaction. Additionally, the errors introduced by the technology continued to exacerbate this noted unpredictability, through presenting different sound variations within the same musical aspect, with no possibility of discerning the pattern of generalization. These errors also limited the collection of empirical data, restricting the analysis to 22 minutes of interaction. In conclusion, the organization of the learning situation, the errors introduced by the technology and the way the technology was set up and used during the learning situation restricted the analysis of what the participants were enabled to discern. Nonetheless, it is still important to investigate what possibilities of learning, though limited, BG enables through the patterns of variation it introduces, in order to evaluate if there are any commonalities with the intended discernment.

The enacted object of learning was characterized by variation in pitch, density, distortion and dynamic accent, neglecting the music aspect of lateralization. According to the researcher's perspective, BG presented the possibilities of discerning high and low pitch, high density, strong distortion and percussive attack. However, these possibilities were also observed as hindered by the pattern of variation of fusion, impeding the possibility of discerning the musical aspects as separate. This resulted in the possible enmeshment of pitch and dynamic accent, and density with distortion. This was also due to the explorative and reticular approach enabled by the technology allowed in the learning situation, which resulted in unsystematic patterns of variation and contrast. Furthermore, the pattern of generalization was also hindered due to technical errors producing inconsistency in repetition and mirroring of the participants' movements, unpredictable variation and unclear contrast between the musical features and the original sound (Marton & Tsui, 2004). This resulted in BG presenting the possibility of discerning the sound changes occurring in the different sounds as distinct and separate. Furthermore, the technology did not consistently allow the participants to discern these distinct sound changes against a context of sound since the pattern of separation that highlighted this context was only experienced in 6 out of 14 sessions.

When comparing this enacted object of learning to previous research that describes the interaction between children and other IRMS technology a disparity in the results is evident. Addessi et al., (2006) describe their participants as experiencing intrinsic motivation, clear goals, excitement and learning whilst interacting with MIROR Impro. These findings are not supported by this study's enacted object of learning, as the children seemed disengaged from the learning situation, aimlessly exploring the technology and repeating the movements shown in the demonstration given by the researchers. The possible contributor to this disparity between studies might be a result of the different conceptualization of learning that the researchers in the previous and current study hold and the different factors identified as pertaining to learning.

Addessi and Pachet (2003) describe learning as, "The moment of excitement" (p. 8). They describe their participants as learning problem solving strategies to master the technology's principles of turn taking, imitation, role taking in order to successfully make use of the

technology. In these moments, the researchers observed excitement in their participants, describing these moments as instances of learning. This description of learning is quite different from the conceptualization of learning brought forward by Variation Theory. As mentioned in the theoretical framework Marton and Tsui (2004) describe learning as the process where the learner becomes aware of what something is and is not through experiencing variation. Therefore, through investigating the contrast created by the variation initiated by the technology, the researcher could speculate what possibilities the children are given to become aware of the intended musical aspects. Therefore, since learning takes on a different meaning in these two studies, different indicators were observed and considered, which led the results in two distinct directions.

Another evident difference between these studies focuses on the content of learning identified. Addessi and Pachet (2003) discuss learning in terms of the participants' fluency in using and interacting with the technology. Their results are somewhat similar to other research within the field of music learning that lack a focus on what domain intrinsic knowledge the learners are encouraged to master (Pramling Samuelsson et al., 2009). Therefore, even though Addessi and Pachet (2003; 2005) provide insightful information about the process of interaction, they do not investigate what specific music capabilities this music technology enables their participants to learn. This current study takes on a different perspective to uncover these specific domain-intrinsic capabilities through shedding light on the lived object of learning.

In the lived object of learning, most of the participants described recurrent contrasts heard in the sounds. However, these contrasts were not attributed to any of the musical aspects identified in the intended object of learning. The participants also seemed to be aware that these created variations in sound are a function of the technology whilst their movements activated these contrast. Similarly to Pramling and Wallerstedt's (2009) participants, the children in this study made sense of these variations in sound by making use of their previous experiences of familiar objects and sounds. Additionally, the participants seemed to perceive different external horizons or contexts at different moments in time, which were all distinct from the intended context of sound. As Wallerstedt (2011) discusses, the context perceived exerts influence on what the listener attends to, and therefore the participants who perceived technology as the context attended to the different parts making up the technology, which influenced their perceived meaning of BG. This was due to the learning situation and technology's failure to establish a common context of sound and relevance structure guiding the participants' in their explorations.

The lack of linguistic distinctions or institutional terms presented by BG (Pramling & Wallerstedt, 2009) also hindered the participants from achieving an already challenging feat of communicating about and "transducing" (p. 147) from an auditory to a verbal modality (Pramling & Wallerstedt, 2009). Similarly to Pramling and Wallerstedt's (2009) sample, the participants compensated for this deficiency by using their own voice, spatial and visual metaphors, and expressing uncertainty. These authors describe language as serving a meta-language purpose that helps the children explain, direct their awareness, make distinctions and formulate relations between what they hear (p. 149). Without these linguistic distinctions, discerning these variations seems to be unachievable, making it even less probable that they discern the variation as functions of the different musical aspects and features.

However, even though the technology and the learning situation did not present the participants with these institutional terms to describe the music aspects, a participant's

description still came very close to a common linguistic distinction used to describe pitch. In excerpt 14 Noel described the sound generated by variation in pitch as changing from *"very high to pretty low"*. This corresponds to a very common dimension of pitch height forming a continuum from low to high (Forde Thompson & Schellenberg, 2002). It seems as though BG enables this one participant to experience clear contrast between the different features of pitch. This matches previous observations made in the enacted object of learning where the researcher observes the technology as presenting clearer pitch changes involving fewer technical errors. However, as Pramling and Wallerstedt (2009) discuss there exists a divide between the "verbal form of knowing" and the "non-verbal kind of knowing" (p. 148). Therefore, even though this participant might be aware of this contrast, even more evidently so with regards to pitch, the technology still does not enable him to identify these variations as corresponding to the specific musical aspects as intended in the intended object of learning.

In conclusion, a learning gap between the lived, the intended and enacted object of learning is significantly evident in this research study. Regardless of the possibilities of learning presented in the enacted object of learning, the technology did not seem to enable the participants to grasp these opportunities. Furthermore, this learning situation within which the technology was evaluated in, is not conducive to learning since it is similar to the pilot-testing situation used to assess for technical flaws. Therefore, this learning situation is not equipped to promote possibilities of learning and thus the participants are not enabled to acquire the intended understanding of the musical aspects. Moreover, the technology did not enable the participants to; discern the context of sound, direct their awareness towards the intended musical aspects, expose the participants to institutional terms to communicating about the sound changes experiences, nor did BG control the patterns of variation in a way to make it possible for the participants to discern the intended understanding.

The Critical Features

Even though the learning gap between the objects of learning is not a positive indicator for the intended discernment, it provides insight into the differences between the learners' and the designers' understanding (Marton & Tsui, 2004). Through analysing these differences and highlighting the learner's difficulties in understanding the intended object of learning (Lo, 2012), critical features were extracted, highlighting what the learners need to become aware of in order to move their understanding closer to the intended object of learning. Thus, in order for BG to enable the participants to discern the intended learning it needs to provide possibilities for the participants to discern these critical features, and also organize the learning situation around these features.

The technology did not provide opportunities for the participants to become aware of the intended part-whole relationship between the musical features and their musical aspects. These parts included the features of high and low pitch, high and low density, strong and no distortion, left and right lateralization and slow and percussive attack. Instead, these sound features were associated to different phenomena, as participants made sense of them by associating them to their previous experiences of similar technology, familiar objects and sounds. Similar to Pramling and Wallerstedt's (2009) sample, the participants in this study seemed to describe the contrast created by these features in relation to the dynamic of the sound rather than to the different musical aspects (p. 141). As Marton and Tsui (2004) argue, learners cannot discern parts without knowing what they are details of (Lo, 2012). Thus, BG's inability to convey a context of sound and the lack of preparation and familiarization to the

different musical aspects and their features during the learning situation made this discernment improbable.

Nevertheless, the participants in this study still try to make sense of these features by making use of the process of appresentation as they focus their awareness on familiar features (Marton & Tsui, 2004). Consequently, without previous experience of sound morphology, Noel immediately discerned BG and its features in the light of his past experience of motion sensors Kinect (excerpt 9). Not only does his previous experience make certain features visible whilst blurring out others, but it also evokes the context the learning situation is understood in. This is evident in the different external horizon identified by the different participants, which give different meanings to the learning situation depending on the participants' previous experiences all differing from the intended object of learning. As noted previously the lack of attempt at familiarizing the participants to the context of sound and sound morphology decreases the possibility for the participants to attend to these intended features.

Additionally, since we learn "about the world through language" (Marton & Tsui, 2004, p. 25) when we experience variation we have the possibility to discern both the contrast created and the language representing that contrast. Through experiencing variation we discern the "linguistic distinctions" (p. 26) and through these linguistic distinctions we are able to discern the variation (Marton & Tsui, 2004). Hence, the inability for BG and the learning situation to impart these linguistic distinctions makes it next to impossible for the participants to discern these sound changes as musical features and to communicate about these musical features as belonging to musical aspects.

Therefore, BG needs to focus the children's attention on these three critical features that include the common context of sound, sound morphology along with its musical aspects and features and institutional terms representing these musical aspects and features. With this new information in mind, how can the learning situation be organised differently? When investigating a similar IRMS technology, the MIROR Impro, Wallerstedt and Lagerlöf (2011) present the teacher's role as a possible solution that meets these needs. Therefore, by introducing this role within the learning situation the children can be assisted to become aware of the context of sound by being guiding to consistently experience the pattern of separation and to reflect that what they hear are all different types of sounds. The teacher could also familiarize the participants to the concept of sound morphology and to its different musical aspects and features. This could be done through conducting a pre-test before the learning situation, to capture the participants' previous experiences of music and sound morphology and evaluate if and what they know with regards to this concept. With this insight, the teacher can then build on the children's previous experiences and introduce institutional terms (Pramling & Wallerstedt, 2009) to equip the participants with linguistic distinctions that will help direct their attention towards the musical aspects and features whilst also assisting the participants in expressing themselves whilst describing the different sound variations. Additionally, the teacher's role has also been noted to make the children aware of certain procedures taken up by technology and motivate the children to explore the technology to strengthen the interest and engagement shown (Wallerstedt & Lagerlöf (2011).

The Participants' Contribution as Research Collaborators

This research study affirms what Burnard (2007) and Laurillard et al. (2009) claim when describing user involvement as essential in evaluating technology. The participants in this study are in fact key stakeholders (Laurillard et al., 2009) as their experiences of the technology uncovered what BG enables them to do (Craft, 2012; Livingstone, 2007). The children in this study demonstrated that BG does not provide them with the possibilities to learn the intended object of learning. Similarly to Wallerstedt and Lagerlöf's (2011) study concerning IRMS, BG seemed to be other than relevant to the participants' everyday life, as none of the participants possessed the previous experience or knowledge to make sense of this interaction created. Hence, contrary to Crow's (2006) review on music technology, BG does not seem to have the potential to reduce the gap between traditional music skills and everyday life experiences of music, since the sound changes it presents are in themselves foreign. The participants' contribution also reinforces the reflections from Linderoth (2010) and Bennerstedt et al., (2012) regarding gamers developing specific skills isolated to the gaming world, since what the participants discerned is specific to this technology.

Nonetheless, the children's collaboration also offers a ray of hope for BG as their lived experiences highlight the critical features needed to acquire the intended object of learning. These critical features also shed light on the needed changes that need to be implemented to the learning situation, as the teacher's role presents a solution to fostering this intended understanding during the learning situation with BG. Thus, the children's collaboration assisted the researcher in acquiring a deeper understanding of learning (Mayall, 2001), generating suggestions to improve this technology and supporting research promoting children as research collaborators (James & Prout, 1997). In return this study provided its participants with a chance to express their voice and influence the development of technology that might affect children's own learning.

Variation Theory as an Analytical Tool

Along with Runesson's (2006) study, this thesis has demonstrated that Variation Theory is a suitable tool to understand learning in a unique setting other than in a classroom situation. It has also proven to be a good tool in understanding music learning, supporting the only other study in this field conducted by Wallerstedt (2011). The theory's focus on what is learnt assisted in deconstructing the object of learning, extracted the intended learning and presenting it in a way that enabled its appraisal against both the enacted and lived object of learning. Most importantly, together with research advocating the involvement of children as research collaborators, it illustrates the usefulness of taking on a second order perspective. As Wallerstedt (2011) argues, Variation Theory guides the researcher to explore the learners' perspectives without judging its validity in order to observe "the relation between subject and (the) object" of music (p. 109), uncovering what is actually discerned.

Additionally, the match between the technology and Variation Theory's similar focus on variation creates an interesting and valuable combination; resulting in the evaluation of the patterns of variation and the possibilities for learning they create. This uncovered a disparity between the intended, enacted and lived object of learning. Variation Theory also provides possible solutions to this gap by generating suggestions through analysing the difference between the designers and children's understanding of the learning situation. These suggestions include introducing the teacher's role to the learning situation, which directs the

children's awareness towards the critical features identified. Therefore, Variation theory has the potential to assist the designers in understanding what the learners are having difficulties with and cater for these difficulties by adapting the technology and the learning situation.

Nonetheless, Variation theory also presents limitations related to its phenomenographic roots. Phenomenography has been criticized for its belief that discourse captured in interviews is a reflection of the different ways people experience a given phenomenon (Säljö, 1997). Säljö (ibid.) argues that alternatively this discourse could be a result of the participants' perceived obligation to reply to the interview questions. This risks the credibility and the internal validity of the study (Shenton, 2004) as data collected from the interviews might not reflect what the study aims to highlight. Since this thesis proposes to capture the learners' perspectives, the implication that what the children shared during the interview may not reflect how they experienced BG threatens both this study's construct validity and the children's representation. As Säljö (1997) explains, the children's 'I don't know' responses could reflect their disinterest in the questions asked rather than represent their experiences.

Furthermore, this limitation brought forward by Säljö (1997) also implies that the participants' limited ways of talking about the learning situation could in fact be an indication of their communication limitations rather than their lack of experiencing the musical aspects. Therefore, Variation Theory might fail to capture this communication limitation when the participants do not have the necessary vocabulary to describe the phenomenon under study. Nevertheless, the suggestions and critical features brought forward by Variation Theory present a possible way forward to compensate for this limitation. Introducing instrumental terms to the learning situation could be both beneficial for the participants to communicate about music and also to experience these linguistic distinctions more clearly. Therefore, even though Variation Theory does not come without its limitations, I chose this theoretical framework because it comes very to close to answering one of the most important question in the field of music education and technology enhanced learning (Crow, 2006; Craft, 2012), of what is possible to learn.

Chapter Six: Conclusion

This final chapter gives an overview of this study's results and their implications concerning BG's future development. This will follow a discussion of the limitations encountered when conducting this qualitative research study and the various steps taken to compensate for these limitations. To conclude, I will outline what this study manages to achieve, where it fails to deliver whilst outlining recommendations for future studies in order to further explore and improve this technology's potential.

Implications of The Results

The critical features of the intended object of learning where found empirically, generated through analysing the participants' difficulties in understanding the intended content. These critical features include the establishment of a common context of sound, knowledge concerning sound morphology, along with their respective linguistic distinctions. In order to implement these new critical features, changes in the learning situation within which the participants interact with BG is needed. One of the needed changes involves including an active teachers' role to enable the learners to become aware of these critical features (Lo, 2012). This entails establishing a relevance structure during the learning situation in order to have common learning goals and objectives to strive towards (ibid.).

Another needed change involves the elimination of explorative approach encouraged by the designers throughout the learning situation. From a Variation Theory perspective this approach created what is known as a sequential structure of the content of learning (Marton & Tsui, 2004). By providing the participants with the freedom to randomly activate the different variation in sounds there is no attempt to connect or relate the different musical features to their corresponding aspects (ibid.). This created a somewhat of a conveyor belt presentation of the different sound changes one after each other. This situation was aggravated by the immediate introduction of the fusion of all musical aspects, making it harder for the participants to distinguish between these variations. This organization of the learning situation was also used previously in the initial pilot testing of BG to test the initial developmental progress of the BG and to screen for technical errors. Whilst this arrangement might have served the purpose of exploring technical errors and recording BG's development, it did not enable the technology to provide adequate possibilities for learning nor did it enable the participants from becoming aware of these possibilities. These observations provide insight that could benefit the research field of technology enhanced learning when evaluating technologies, to implement experimental designs or arranged learning situations that are conducive to learning in such a way that the evaluated technology is facilitated to promote its possibilities of learning.

With regards to this study's learning situation, it could have been designed differently through introducing variation in a hierarchical way that demonstrates clear part-whole relationships between the musical features and their aspects, increasing the possibilities of discerning the intended object of learning (Marton & Tsui, 2004). This modification would entail the involvement of a teacher who introduces the participants to the learning objective of becoming aware of the different music aspects, presents the pattern of variation of separation of each aspect and focuses the participants' awareness on each feature. Since previous experience was also demonstrated as having an influential role in discernment, there is a need

to establish a pre test framework where the children's previous experiences and understanding of the sound morphology, musical aspects and features is uncovered before any learning is attempted. By comparing their previous understanding to the intended understanding, the educator can grasp the difference between these two, identify what is missing from the learners understanding and present critical features that assist the learners to move to a more powerful and intended way of seeing the phenomenon being learnt (Lo, 2012). Therefore, even though BG has a lot more to perfect with regards to its technology in terms of errors and unpredictability, it seems to need additional factors to prepare for the learning situation and within this situation, that are as yet not possibly delivered solely by the technology itself.

Limitations

These mentioned above results provide important implications to improve BG and this learning situation in order to support these 6 participants to become aware of the designers' intended understanding. As mentioned previously due to the use of convenience sampling these implications are limited to support these 6 participants since this type of sampling method opens the study to limitations with regards to population generalizability. Moreover, the unique arranged learning situation, convenience sampling and small sample size further contribute to the uniqueness of this study, threatening the possibility of transferring these results to other naturalistic settings (Shenton, 2004) or generalizing these implications to support other children (Wallen and Fraenkel, 2000). Nonetheless, steps were taken to decrease this limitation through presenting detailed descriptions of the context with abundant contextual information and detailed proceedings of the arranged learning situation (Shenton, 2004). This detailed information improves the dependability of the study, as these descriptions increase the chances of replication and obtaining similar results (ibid.). Even though these descriptions are beneficial, the arranged learning situation is still problematic as it limits the empirical data collected that could be in turn analysed. This limits the discovery potential of this study limiting any claims with regards to the participants' learning. However, this narrow empirical data still highlights the patterns of variations initiated by BG, which in turn were used to hypothesize what discernment they might have produced. These were later compared to the learners' perspectives in order to confirm or refute these hypotheses. Furthermore, this study provides useful insight concerning the organization of learning situations used to evaluate the learning potential of technologies through making use of Variation Theory principles.

These limitations brought forward by the use of convenience sampling create the need to replicate the study in order for the findings to be used and transferred to the wider population of children. This need will involve conducting another study with a number of different samples to find out if the results were a result of a one-time occurrence (Wallen & Fraenkel, 2000). Therefore, if the critical features identified in this study reappear in the second study, the possibility to generalize the generated implication to the wider population will increase, increasing the external validity of the study (Wallen & Fraenkel, 2000). However, at this point in time this study can only provide important insights to its original focus of exploring the distinct ways in which six participants experienced this learning situation with BG, providing answers to the research questions posed. Furthermore, these implications also contribute to the knowledge base of technology enhanced learning as these results shed light on the limitations of a new prototype BG to enhance learning and provide evaluative feedback with regards to how it can be improved. This is even more important since no previous

research within technology-enhanced learning or music technology have investigated this new technology.

When conducting qualitative research and using methods such as observation and interpretation, there is always a risk of limiting the study's credibility equivalent to the concept of internal validity which deals with the question of if the study measures or answers what it intends (Shenton, 2004). These methods may expose data to researchers' bias and prejudices and as a result hinder researchers from ensuring "that their study measures…what is actually intended" (Shenton, 2004, p.64). This poses a great risk since the priority of this study is to represent the participants' perspectives as genuinely as possible. However, certain steps were taken to increase the credibility and the internal validity of the study. As suggested by Shenton (ibid.) this study uses methods that have already been used by successful studies that effectively uncovered the learners' perspectives and evaluate learning. Runesson (2006) used observation, analysis of language uttered by a girl who interacted with a learning enhancing technology, and also Variation Theory as an analytical tool whilst Wallerstedt (2011) also used observation, interviewing and Variation Theory to evaluate learning. Likewise, Wallerstedt and Lagerlöf (2011) used observation and interviews to evaluate the learning outcomes of an IRMS technology MIROR Impro. Furthermore the use of multiple methods and triangulation continues to strengthen the study's credibility as the different methods compensate for each other's limitations (Shenton, 2004). This is also true when the study uses triangulation in terms of perspectives (ibid.), as the designers, researchers and children's perspectives were taken in consideration in order to formulate the mentioned above results.

Recommendation for Future Research

This learning situation created for evaluative purposes is unique. As mentioned above this uniqueness can limit the study's transferability. Therefore, a recommendation for future research would entail evaluating BG in naturalistic context such as in a school setting. Preferably these future studies would have incorporated the improvement suggested to the learning situation to evaluate if the role of the teacher and the new critical features increase the possibilities for learning the intended object of learning. Nonetheless, the unpredictable nature of the technology might still limit these future studies transferability and dependability since the chances of obtaining similar results in the similar or different contexts might still be restricted (Shenton, 2004). Therefore, this unpredictability needs to be addressed and amended by the designers, since the technology cannot be described and promoted as resulting in the intended object of learning if the same variations and possibilities cannot be confirmed from one learning situation to another. Thus, further research is necessary in order to continue to promote improvements in BG.

This study has highlighted that the knowledge tackled in this intended object of learning involving BG is distinct from the participants' experience of sound in their everyday life. Since there is the ambition to distribute this technology in schools it becomes important to investigate BG with its new improvements in this setting. This new avenue of research would shed light on the relevance of the intended object of learning to the educational settings and the traditional music curricula. It would also be interesting to investigate how a music teacher within this school setting can use this technology to teach other objects of learning to develop other capabilities promoted in music education.

In conclusion in this study I managed to highlight the designers' understanding of the intended object of learning, collect restricted but still informative data with regards to the patterns of variation occurring in the enacted object of learning whilst comparing these to the external and internal horizons identified by the participants. This analysis also led to the discovery of the critical features that need to be promoted in order to foster the intended understanding and of the role of teacher as a tool to highlight these critical features. However, I failed in capturing the participants' prior understanding of sound morphology through failing to conduct a pre test in order to investigate if the technology produces a difference in the learners' understanding. Furthermore, the participants were not adequately prepared to make meaningful use of this technology. These shortcomings were due to the framework imposed on this study by protocols encouraged within the MIROR research project along with time and financial constraints. Nonetheless, this study sheds light on important implications to overcome these limitations through implementing the suggested changes to the learning situation whilst encouraging the designers to amend the unpredictability introduced by the technology. More is to be done with regards to evaluating the learning potential of this technology, however this study demonstrates the usefulness of including children as key stakeholders within research, the effectiveness of using Variation Theory to understanding learning whilst providing initial findings that are useful as feedback to improve both the technology and the learning situation.

References

Addessi, A. R. (2012). The MIROR Platform: Theoretical framework and concepts. In *Deliverable 2.2.1 First Chapter*, 1–45.

Addessi, A. R., & Pachet, F. (2005). Experiments with a musical machine: Musical style replication in 3 to 5 year old children. *British Journal of Music Education*, *22*(1), 21–46.

Addessi, A., & Pachet, F. (2003). Children's Interaction with a musical machine. *3rd Conference Understanding and Creating Music*, (December), 11–15.

Addessi, A., Ferrari, L., Carlotti, S., & Pachet, F. (2006). Young children's musical experiences with a flow machine. In *Proceedings of the 9th International Conference on Music Perception and Cognition*, 1658–1665.

Benghi, D., Addessi, A., & Pachet, F. (2008). Teaching to improvise with the Continuator. *28th International Society for Music Education World Conference*, (July), 2008.

Bennerstedt, U., Ivarsson, J., & Linderoth, J. (2012). How gamers manage aggression: Situating skills in collaborative computer games. *International Journal of Computer-Supported Collaborative Learning,* 7(1), 43-61.

Berk, L. E. (2006). *Development through the lifespan*. Boston: Pearson Education Inc.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative research journal*, *9*(2), 27-40.

Bradley, K. K. (2009). *Rudolf Laban.* New York: Routledge.

Browne, K. D., & Hamilton-Giachritsis, C. (2005). The influence of violent media on children and adolescents: a public-health approach. *The Lancet*, *365*(9460), 702–710.

Bryman, A. (2004). *Social research methods*. Oxford: Oxford University Press.

Burnard, P. (2007). Reframing creativity and technology: Promoting pedagogic change in music education. *Journal of music, Technology and Education*, *1*(1), 37–55.

Chitakunye, P. (2012). Recovering children's voices in consumer research. *Qualitative Market Research: An International Journal*, *15*(2), 206–224.

Clarke, D. (2002.). The learner's perspective study: Exploring the potential for complementary analyses. *Annual Conference of the American Educational Research Association*. New Orleans: USA.

Corbin, J., & Strauss, A. (2008). Theoretical sampling. In Basics of Qualitative Research (3rd ed.): Techniques and Procedures for Developing Grounded Theory. Corbin, J., & Strauss, A. (2008). Thousand Oaks, CA: Sage Publications, Inc.

Cordes, C., & Miller, E. (2000). Fools gold: A critical look at children and computers. *The Alliance for Childhood, College Park, MD*.

Craft, A. (2012). Childhood in a digital age : Creative challenges for educational futures. *London Review of Education*, *10*(2), 173–190.

Crow, B. (2006). Musical creativity and the new technology. *Music Education Research*, *8*(1), 121–130.

Dempsey, P. (2010). Stimulated recall interviews in ethnography. Qualitative Sociology, 33(3), 349-367.

Dockett, S., Einarsdottir, J., & Perry, B. (2009). Researching with children: Ethical tensions. *Journal of Early Childhood Research*, 7(3), 283-298.

Forde Thompson, W., & Schellenberg, E. G. (2002). In R. Colwell, & C. Richardson (eds.), The handbook of research on music teaching and learning (pp. 461-486). New York: Oxford University Press.

Gadamer, H. G. (1975). *Truth and Method. W. Glen-Dopel, London: Sheed and Ward*.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan Limited.

Gibson, J. J., & Gibson, E. J. (1955). Perceptual learning: Differentiation or enrichment? *Psychological Review*, *62*(1), 32–41.

Hargreaves, D. J. (1986). *The developmental psychology of music*. United Kingdom: Cambridge University Press.

Hartas, D. (2010). Educational research and inquiry: Qualitative and quantitative approaches. London: Continuum.

Hill, M. (2006). Children's voices on ways of having a voice: Children's and young people's perspectives on methods used in research and consultation. *Childhood*, *13*(1), 69–89.

Holmqvist, M., Gustavsson, L., & Wernberg, A. (2009). Generative learning: Learning beyond the learning situation. *Educational Action Research*, 15(2), 181-208.

James, A., & Prout, A. (1997). *Constructing and reconstructing childhood: Contemporary issues in the sociological study of childhood*. London: Falmer Press.

Kendon, A. (1997). Gesture. *Annual Review of Anthropology*, *26*, 109–128.

Kleining, G., & Witt, H. (2001). Discovery as basic methodology of qualitative and quantitative research. *Forum: Qualitative Social Research Sozialforschung*, 2(1), 1-26.

Koffka, K. (1922). Perception: An introduction to the Gestalt-theorie. *Psychological Bulletin*, *19*(10), 531-585.

Laban, R. (1980). *The mastery of movement (4th edition).* United Kingdom: Northcote House.

Lange, A., & Mierendorff, J. (2009). Method and methodology in childhood research. In J. Qvortrup, W. A. Corsaro, & M. S. Honig (eds.), *The Palgrave Handbook of Childhood Studies*, (pp. 78–95). Basingstoke: Palgrave Macmillan.

Laurillard, D., Oliver, M., Wasson, B., & Hoppe, U. (2009). Implementing technology-enhanced learning. In N. Balacheff, N. Ludvigsen, S. Jong, T. Lazonder, & S. Barnes (eds.), *Technology-enhanced learning*, (pp. 289–306). Dordrecht: Springer Netherlands.

Linderoth, J. (2010). Why gamers don't learn more: An ecological approach to games as learning environments. *Nordic DiGRA*, 1–8.

Livingstone, S. (2007). Do the media harm children? *Journal of Children and Media*, *1*(1), 5–14.

Lo, M. L. (2012). *Variation theory and the improvement of teaching and learning*. Göteborg: Acta Universitatis Gothoburgensis.

Lombardi, M. (2007). Authentic learning for the 21st century: An overview. Educause Learning Initiative, 1, 1–12.

Marton, F., & Booth, S. (1997). *Learning and awareness*. New Jersey: Lawrence Erlbaum.

Marton, F., & Tsui, A. B. (2004). *Classroom discourse and the space of learning*. New York: Routledge.

Mayall, B. (2001). The sociology of childhood in relation to children's rights. *The International Journal of Children's Rights*, *8*, 243–259.

Meyer, J. P., Cash, A. H., & Mashburn, A. (2011). Occasions and the reliability of classroom observations: Alternative conceptualizations and methods of analysis. *Educational Assessment*, *16*(4), 227-243.

MIROR, (2012). Deliverable D2.2.1-1st Chapter, The MIROR Platform: Theoretical framework and concepts, 1–45.

MIROR, (2012). Deliverable D2.2.1, Yearly Updated Specification Document (Revised Version), 1-84.

MIROR, UNIGE, (2012). Deliverable D4.3.2, MIROR-Body Gesture, 1-43.

Mulhall, A. (2003). In the field: notes on observation in qualitative research. *Journal of advanced nursing*, *41*(3), 306-313.

Pachet, F. (2002). Playing with virtual musicians: The Continuator in practice, *IEEE Multimedia,* 9(3), 77-82.

Papousek, M. (1995) as cited in MIROR, (2012). Deliverable D2.2.1-1st Chapter, The MIROR Platform: Theoretical framework and concepts, 1–45.

Piaget, J., & Inhelder, B. (1958). *The growth of logical thinking from childhood to adolescence: An essay on the construction of formal operational structures* (Vol. 84). Routledge.

Poland, B. D. (1995). Transcription quality as an aspect of rigor in qualitative research. *Qualitative Inquiry*, *1*(3), 290–310.

Pramling Samuelsson, I., Asplund Carlsson, M., Olsson, B., Pramling, N., & Wallerstedt, C. (2009). The art of teaching children the arts: music, dance and poetry with children aged 2–8 years old. *International Journal of Early Years Education*, 17, 2, 119-135.

Pramling, N., & Wallerstedt, C. (2009). Making musical sense: The multimodal nature of clarifying musical listening. *Music Education Research*, *11*(2), 135-151.

Pring, R. (2004). *Philosophy of educational research*. London: Continuum.

Qvarsell, B. (2005). Early childhood culture and education for children' s rights. *International Journal of Early Childhood*, *37*(3), 99–108.

Qvortrup, J. (2004). Editorial: The waiting child. *Childhood*, *11*(3), 267–273.

Rowe, V. C. (2009). Using video-stimulated recall as a basis for interviews: some experiences from the field. *Music education research*, *11*(4), 425-437.

Runesson, U. (2006). What is it possible to learn? On variation as a necessary condition for learning. *Scandinavian Journal of Educational Research*, *50*(4), 397–410.

Säljö, R. (1997). Talk as data and practice: A critical look at phenomenographic inquiry and the appeal to experience. *Higher Education Research and Development*, 16(2), 173-190.

Schiller, W., & Einarsdottir, J. (2009). Special issue: Listening to young children's voices in research – changing perspectives/changing relationships. *Early Child Development and Care*, *179*(2), 125–130.

Scriven, M. (1991). Prose and cons about goal-free evaluation. *American Journal of Evaluation*, *12*(1), 55–62.

Scriven, M. (1996). Types of evaluation and types of evaluator. *American Journal of Evaluation*, *17*(2), 151–161.

Sergeant, D., & Roche, S. (1973). Perceptual shifts in the auditory information processing of young children. *Psychology of Music*, *1*(2), 39-48.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, *22*, 63–75.

Sjöström, B., & Dahlgren, L. O. (2002). Applying phenomenography in nursing research. *Journal of advanced nursing*, *40*(3), 339-345.

Sommer, D., Pramling Samuelsson, I., & Hundeide, K. (2010). Child perspectives and children's perspectives in theory and practice. In *International Perspectives on Early Childhood Education and Development* (pp. 151–161). Dordrecht: Springer Netherlands.

Stern, D. (1977). *The first relationship: Infant and mother*. Cambridge: Harvard University Press.

Suri, H. (2011). Purposeful sampling in qualitative research synthesis. *Qualitative Research Journal*, 11(2), 63-75.

Swedish Research Council (2012). *CODEX: Rules and guidelines for research.* Retrieved from http://www.codex.vr.se/en/index.shtml.

Tapscott, D. (2009). *Grown up digital*. New York: McGraw-Hill.

Tomm, K. (1998). A question of perspective. *Journal of Marital and Family Therapy*, *24*(4), 409-413.

United Nations. (1989). Convention on the Rights of the Child. Retrieved from www2.ohchr.org/English/law/crc.htmhashart12.

Vandewater, E. A, Rideout, V. J., Wartella, E. a, Huang, X., Lee, J. H., & Shim, M. (2007). Digital childhood: electronic media and technology use among infants, toddlers, and preschoolers. *Pediatrics*, *119*(5), 1006–1016.

Wallen, N. E., & Fraenkel, J. R. (2000). Educational Research: A Guide to the Process. Mahwah, N.J: L. Erlbaum.

Wallerstedt, C. (2011). Didactic Challenges in the Learning of Music-Listening Skills. In N. Pramling, & I. P. Samuelsson (eds.), *Educational encounters: Nordic studies in early childhood didactics* (pp. 105-126). London: Springer Science Business Media.

Wallerstedt, C., & Lagerlöf, P. (2011). Exploring turn-taking in children' s interaction with a new music technology. *Hekupu.ac.nz*, 20–32.

Webster, P. (2011). Key research in music technology and music teaching and learning. *Journal of Music, Technology and Education*, *4*, 115–130.

Young, J. (2004). Sound morphology and the articulation of structure in electroacoustic music. *Organised Sound,* 9(1), 7–14.

Young, S. (2006). Interactive music technologies in early childhood music education. In *9th International Conference on Music Perception and Cognition*, 1207–1211.

Appendices

Appendix 1

MIROR Project is an international collaborative research project, were designers, psychologists and educationalists collaborate together in creating and evaluating new technology to contribute to the field of music education (MIROR_D2.1.1.P1). This project was launched on the 1st September 2010, coordinated by Dr Anna Rita Addessi from the University of Bologna and is co-funded for 3 years by the European Community under the Information and Communication Technologies (ICT) 7th Framework Programme. Four psycho-pedagogical partners including European universities such as University of Gothenburg, University of Athens, University of Exeter and University of Bologna have teamed up with technical partners at the University of Genoa, Sony France Computer Science Laboratory and COMPEDIA Software and Hardware Ltd., to investigate and evaluate the use of this technology in early childhood education.

The Gothenburg psycho-pedagogical team (UGOT) is made up of Professor Ingrid Pramling Samuelsson, Professor Niklas Pramling, Senior Lecturer Åsa Bergman, Dr. Cecilia Wallerstedt, doctorate student Pernilla Lagerlöf, master student Sarah Mercieca led by Professor Bengt Olsson. As a psycho-pedagogical partner, the team's responsibility is to conduct psychological and pedagogical experiments in order to investigate the creative music processes produced by the interaction between music software and children. Studies were conducted on three different software platforms, each involving a different musical skill such as improvisation (Continuator & newer version MIROR Improvisation), composition (MIROR Composition) and body performance (MIROR Body Gestures). These technologies were both developed and validated in the light of early childhood music education. The focus of these studies conducted within this project centred around musical learning, with the aim of developing the technology's potential, in order to create new forms of pedagogical software to be commercialized and used in formal and informal settings.

Appendix 2.1: The Arranged Learning Situation

For this explorative study of The Potter the researchers at UGOT decided to split the 6 participants in 3 pairs, each pair participating one after the other. A pair was escorted to the room where the technology was set whilst the other two pairs were in a near by room with another researcher playing and drawing together as they waited their turn. Each child in the pair interacted with the technology on his or her own due to the technology's own limitations. Initially 3 sound sets, each including 3 different sounds for each cylinder, were selected to be investigated by each pair. The first set represented melodic sounds (clarinet, girl's singing voice and guitar), the second set represented naturalistic sounds (fire, sea and water) and the third set represented experimental sounds (cricket, telephone and voice recording options). However as the exploration went on it was decided that only one pair would explore all the 3 sounds sets due to time limitations. The remaining pair where asked if they wanted to use the voice recording option where they could record their own sound to explore. The pair that agreed experimented with the experimental and melodic sound sets whilst the pair that declined the offer explored the naturalistic and melodic sound sets. Each child was free to choose which sounds to use from each set, the order and time he or she spent on each sound, or if to use all the sounds in each set or just a few.

3 Sound Sets	3 Sounds per set	Participants	Sound Parameters Activated
Melodic Sounds	Girl's singing voice	Pair 1 (2) Pair 2 (2) Pair 3 (2)	Pitch Lateralization Distortion Dynamic Accent Density
	Guitar		
	Clarinet		
Naturalistic Sounds	Water	Pair 1 (2) Pair 2 (2)	
	Sea		
	Fire		
Experimental Sounds	Cricket	Pair 1 (2) Pair 3 (2)	
	Telephone		
	Voice Recording		

Table 14. The Potter Sound Sets, Number of Participants Interacting with Sets and Musical Aspects Activated

The researchers and the technicians had agreed to enable all sound parameters for all sets and sessions (pitch, lateralization, density, dynamic accent and distortion) since they had already observed the parameter of pitch in a previous pilot study and now wanted to explore how this parameter performed together with other parameters.

Appendix 2.2: Warm Up Session

The warm up session was divided in three different activities with the aim of familiarizing the children with both the researchers and with the gestures necessary to operate BG. The first activity involved throwing a ball to each other whilst the children formed a circle, where with each throw the participants called out their names. This encouraged the children to experiment and get familiar with different ways of moving and throwing a ball. As recommended by other collaborators within the MIROR project (MIROR_D2.2.1) this activity was going to assist the children to strengthen their abstraction ability necessary to make use of The Potter, by providing concrete examples of the movements they are required to perform before the technology with a so called imaginary ball. Similar to other collaborators within the project, UGOT identified this ability as a challenge in a previous pilot study of the Potter, as the participants seemed to have difficulties with maintaining this imaginary ball metaphor throughout their interaction. The second activity involved the children moving around the room and changing the way they move when one of the researchers clapped their hands. The children were directed to vary the levels they were moving in by stretching up as they walk or crawling to the ground as they move around. They were also directed to change the characteristics of the movement by pretending to move like a kangaroo, woodsman and airplane. This would prepare the children to move in ways that are expected by both The Potter and BeSound. The last activity assisted the children to experience hand gestures such as compressing, stretching and bouncing, as the children were encourages to use these above gestures to explore different objects such as ropes, plush toys and balls. These gestures are all useful in operating The Potter and their exposure would help the children in becoming familiar with using this technology. This warm up session was conducted in Swedish where the children were presented with a number of flashcards indicating the movements necessary in each activity whilst also receiving further verbal instructions in Swedish.

Appendix 2.3: Procedures Extracted from MIROR_D4.3.2 (p. 11)

The activity is carried out with the supervision of a teacher. The teacher:

- Chooses a set of sound objects.
- Fills the sound pots (physical objects) with the selected sound object.
- Chooses the movement mapping, i.e., which parameters of the sound objects are subject to manipulation. This may range from one single parameter to a collection of parameters, depending also on the pedagogical objectives of the teacher. For example, the teacher may decide to focus on a single parameter at a first stage in order to make the child aware of the variation of such a parameter, and move at a second stage to more complex mappings, involving more parameters.

The child:

- Takes a sound pot from the draft area.
- Puts the pot in the listening area, to listen to the sound object the pot contains. The whole sound object will be reproduced once.
- Grasps the pot and takes in her hands the corresponding sound.
- Manipulates the sound object with her movement. The processed sound is reproduced in loop as long as the child keeps moving.
- Can freeze for a few seconds, causing the resulting sound to be stored. The child can then put again the sound in its pot and place it in the final area. This will be the crafted sound.

Appendix 3: The Observer XT

The Observer is a data analyzing software that assists researchers in video observation and analysis. The researcher must first prepare a coding scheme corresponding to the behaviour he or she is studying. When importing the video data to the software, the researcher can simultaneously watch and code the behaviour, recording the exact time it occurs. This information can be used to produce visualizations to demonstrate the progress, frequency and pattern of the behaviour. Figure 12 demonstrates an observation session illustrating the video data, coding scheme (right column) and visualization beneath the video data.

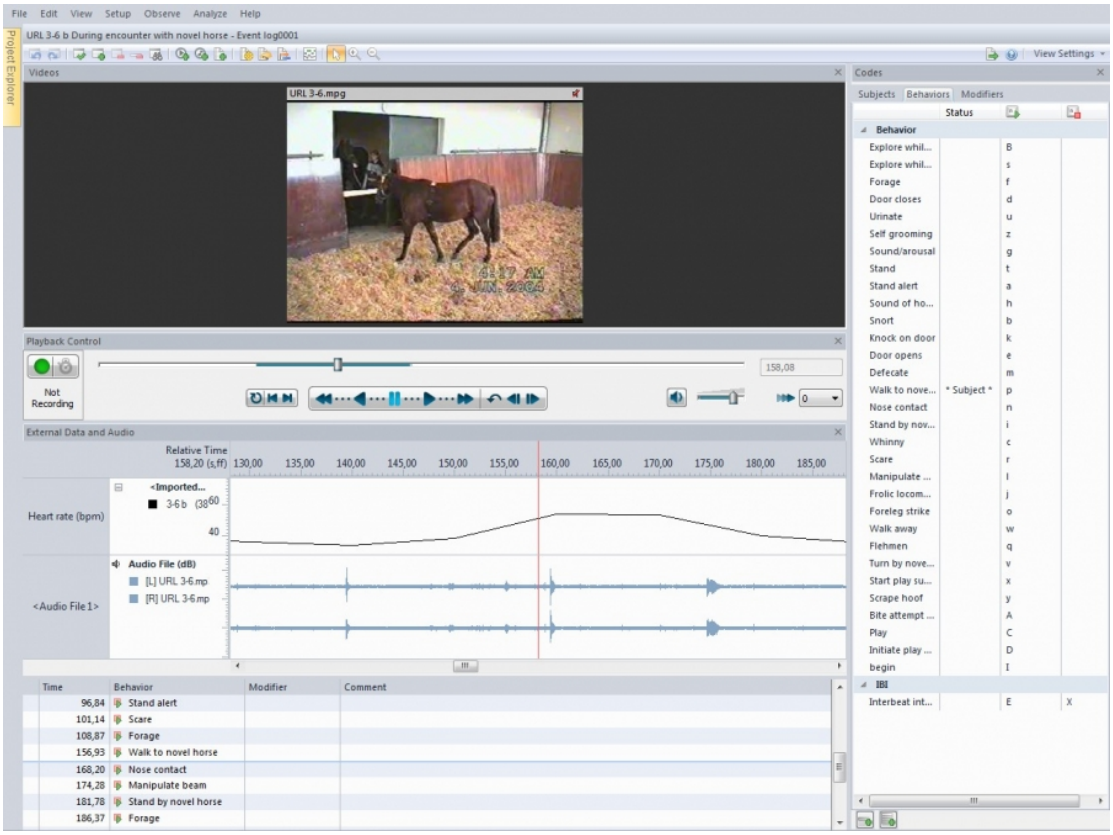


Figure 11. The Observer XT Print Screen; Retrieved from http://www.noldus.com/animal-behavior-research/products/the-observer-xt