ABSTRACT
Recent years have shown a broad spectra of tangible interfaces or TUI's, based upon interaction with music, but also other interfaces containing ubiquitous computing. This is an interesting field due to how engaging music can be and work as connector between people. But the field of human computer interaction has some explorational properties. This paper presents an idea of abstraction with a tangible interface for creating music. The idea behind abstraction of the interface is to engage the user(s) in exploring the artifact, rather than explaining the artifact to the user what can and cannot be done with the artifact.

AUTHOR KEYWORDS
Tangible; Tactile; Music; TUI; Abstraction; Interaction Patterns;

INTRODUCTION
This paper presents a study of a tangible music artifact with the name of Cubieo, the idea behind the study is the properties of tangible interfaces or TUI's with an approach to abstract interaction. With abstract interaction the focus on this artifact is that the notion of an easy to understand artifact with well explained and intuitive interface of interaction has been abolished to give way for the exploratory properties for the user to discover how the artifact works. The idea was to focus on the perception for the user in an installation like setting where the artifact is more focused on user experience than efficiency of use and a well explained tangible interface.

In this paper the qualities and user experience of the artifact are discussed and evaluated. The tangible interface was observed in two semipublic settings and evaluated through observations.

The questions that are asked is:
• How does the idea of abstraction in the tangible user interface work.
• In a setting where the user has no prior idea or experience of how the artifact works.
• What patterns of interaction will emerge.

BACKGROUND
The synergy of music and human computer interaction can be found in research from the 1970's and 1980's contributed by William Buxon [14].

Buxton writes that there are three levels of design: standard specification, military specification, and musical or artist specification, the third and last is the most important and hardest to design [14]. The musical/artist specification, presents most challenges due to the expertise it takes to master these instruments and tools for composing and making music, but also due to the investments of time the niched group of people have invested in learning an instruments, e.g. master a craftsmanship such as painting. These professionals have high requirements of the tools they use [4].

From a musical standpoint, in human computer interaction there are some limitations for control and expressiveness according to Jeff Pressings study on the sound control of a violin and a standard MIDI keyboard. The MIDI keyboard uses less than ten dimensions [19]. Wanderley proposes gestures as a basic method of interaction, and how these gesture taxonomy can relate to different sound control tasks [23]. There have been devoted attempts bringing musical
interaction and the representation of objects and with different techniques of interaction to give the user a musical experience through interactivity with different devices and creating an experience for the user in the domain of sound control [14].

Tangible user interfaces have a property of giving the user a tactile-visual feedback of the interaction and the representation of the action can be attached to the objects to suggest what kind of interaction that might be needed, the objects have “affordances”. The idea of affordances was first presented by James J. Gibson in 1977 with the book “The Theory of Affordances.” [12].

Norman [17] describes the notion of affordance as the objects have inviters of behavior, for instance, a chair has the affordance of sitting on. This works for all objects and depends on how the user perceives the interaction.

However, a tabletop computer with a qwerty setup, a mouse and keyboard for basic interaction leave the user with only a few options for interaction e.g. click, drag or input from the keyboard which can be seen as a click. The affordances are represented in the graphical interface, for instance knobs, levers or buttons. These affordances of interaction is what Norman describes as perceived affordances, the interactive quality of the object lies in the perception of the user [17].

The idea of a tangible interface is to use the more haptic and expressive interaction that human experience in the everyday life and give a better context for the interaction for the use also is connect actions with movement something which helps the users motor memory. A tangible user interface or TUI, also has affordances that a GUI lacks, such as feel of an object and direct manipulation thus giving the GUI a lesser experience for the user. Other effects that the artifact embraces towards the user is the atmosphere where the artifact is placed. Atmosphere is a word that is interchangeably used for feelings, tone or mood. All of these qualities are other ways of naming collective affects as Ben Anderson [2] writes “In everyday speech and aesthetic discourse”. This concept will be further defined later in the text.

In this paper I suggest that the concepts of abstract tangible interaction could be a fun, engaging, creative and affective way of interaction.

IDEA AND RATIONALE

The basic idea behind the Cubieo project is to create an artifact with a tangible interface for controlling and in some sense creating music. A tangible interface compared to other computer systems makes more use of the users sensory and motor systems [13].

The idea behind Cubieo is an artifact to creating a musical experience through abstract interaction with different shaped geometrical controllers.

The idea of geometrical controllers to interact with the music is that the user does not have a predefined perception of how the controllers are used as the user would have of a lever or a button [17].

Cubieo is an exploration through design of an idea of abstract interaction to explore how the user engage scrutiny of the user.

The ludic approach for this artifact is to engage homo ludens, the playful human [11]. People learn and explore by playing, and this is one of the inviters of behavior for the artifact [10]. Without problem an exact way of interacting with Cubieo it gives the user a freedom of use and an possibility for appropriation in exploration [10].

The artifact created in this study is a tool for observation of user behavior in tangible interfaces and is not created to solve a specific problem that could occur for a user.

The question asked is: “What patterns emerge when users are faced with an abstract interaction for music?”

RELATED WORK

There has been a lot of research around tangible interaction with music in different shapes and sizes. Music and exploratory interaction principles work well together because music is an engaging medium for the user, and a direct feedback is possible that will give the user a feeling of reward and control of the interaction. The way a user can interact through tangible music interfaces are endless and restricted to the imagination of the designer and the intentions of the user.

There has been a lot of different tangible music devices for making live music and installations, for instance the Brain Opera [18] which stimulate and give musical and visual feedback to the person interacting with it. Depending on how the user interacted the feedback changed in the system.

When it comes to artifacts related to musical interaction combined with human computer interaction abstraction is a core element. For instance the reacTable consists of several different cubes that control sound samples, and with these cubes the user selects and manipulates the system [14].

One can ask one self how the relationship between cubes and musical interaction is related, but this also goes for other artifacts such as the Brain Opera where several different ideas of interaction and manipulating sound are presented, from handlebars of a motorcycle to sensors that triggers different sounds through hits from the user [18].

In the paper "Contact through canvas: an entertaining encounter” Van Boerdonk et al. [21] present a wall that generates sound if users that stands on different sides of the wall touch, and depending on which body part the sound changes [18].

In the ideas presented earlier there is a level of abstraction and the focus is more on inviters of behavior. The different research projects presented do not provide one absolute way of interaction, but several. The different ways of interaction give the user of the artifact a freedom to use it as he or she perceives it should or could be used.
To compare these ideas of interaction, and how a user interacts with an instrument is hard. The interaction with an instrument is an absolute way, there is "right" and "wrong". However, none of these installations should be compared with an instrument directly. Instead the installations use music as an inviter of behavior for interaction, and a method of spurring the creativity and fun for the user. The Cubieo project uses some of the ideas presented in the different articles and projects presented earlier and the aim is to use them in a novel way. For instance the abstraction, of the reacTable and how the user manipulates the music is predefined in the software of the artifact. But in Cubieo there is some pre-definitions of what can and cannot be done, but depending on the users input the outcome can be vary and the idea of a "good" sound is left to the scrutiny of the user. The Cubieo project is not a new way of creating music and does not aim to replacing existing instruments.

**THE CONCEPT PHASE**

The concept behind Cubieo began as an idea where tangible interaction was the center and where the idea was that the feedback for each interaction should be instant. The first ideas were more basic than the final prototype, inspiration came from ideas like the MusicCube [2] where the user interacts with a luminance cube to browse through playlists in their music library and BrainOpera which both gives a music feedback and a visual feedback to the users interaction [18]. Our approach to what we would build had some constraints in time and technology as well as funding issues, and we needed to find workarounds these problems.

One early idea were that the user should stroke an object that had a similar shape to a whale to create music. The skin of the whale would be covered in capacitive sensors and the different combinations of sensors that would be touched would generate music and the whale would "sing", much like the octopus presented in the paper "Sharing the Squid: Tangible Workplace Collaboration" [20]. However, these ideas were not advanced enough to satisfy our ideas for the interaction. After brainstorming around different technologies and sensors we came up with the idea of light driven interaction for music and an abstract approach to the principle of interaction. After brainstorming around different technologies and sensors we came up with the idea of light driven interaction for music and an abstract approach to the principle of interaction. The drive behind the users actions would curiosity and inviters of behavior, and this could be a installation like environment where the users tried what they wanted. There would be no wrong or right, the goal would be only to create a musical experience for the user through abstract objects and freedom of use.

**THE ATMOSPHERE**

Cubieo facilitates more than being a tangible interface. The artifact is placed in a suggestive atmosphere. Through this atmosphere is to be understood as a metaphor where the artifact is placed, the representation of the objects in the artifact will be apprehended in a context that provides a suggestive atmosphere [4].

The complexity of the term "atmosphere" is vast and expresses something vague, a ill-defined notion is hard to concretize through definition and rational explanation.

The term atmosphere has affective qualities, the qualities given to "atmosphere" is often singular of expressing its affective qualities: melancholic, pleasant, depressing, inviting only to name some [2].

There for expressions that are associated with aesthetic objects are not self enclosed instead they are affected by the atmosphere which the object is presented.

Values, social and cultural background are factors to affect the perception of the artifact. "The singular affective quality of an aesthetic object is ‘open’ to being ‘apprehended’ through feelings or emotions." [2]. In this way the represented artifact is affected by the atmosphere which it is presented in.

Atmospheres are unfinished and can be created to fit the desired artifact for a coherent experience. They "Atmospheres" are resources that become elements within sense experience [2]. In this way Cubieo facilitates the setting where it is being placed in.

**TECHNOLOGY**

The technology used in the artifact for the interactive capabilities are light sensitive sensors connected to a phidget usb interface kit which works as a controller for the sensors and this interface kit, a Wii-mote and a RFID antenna are also connected to the laptop. The readings from the light sensors and Wii-mote give a reading from 0-1000 and the RFID reads a serial number from a card. The readings from the sensors are routed in to MAX/MSP which is a graphical programming language. The Wii-mote is connected through OSCulator and routed to MAX/MSP.

The software that controls the sound from the interactions is programmed inside MAX/MSP and then routed out through the laptop to a speaker system in the room where the artifact is placed.
ABSTRACTION AND TANGIBLES

The prototype consists of what could be described as three modules, each facilitating three levels of abstraction. All of these tangibles are placed on a table with a lightbulb in the centre. The different sensors and ways for interaction are six light sensitive cubes, a rubber foam ball and two soft pads. All the cubes are painted in a modernistic style. The choice of an abstract, rich color scheme is intended to invite users for interaction and make the prototype look less "hard". The color scheme is also chosen to evoke an affective atmosphere for the user as described above how an object can enhance the space of the context it is presented in [2].

The first system module is a drum machine playing a four by four beat. The controls for this one consists of four cubes with light sensitive sensors inside, and set to a span from zero to five. Each cube controls one drum on the four by four drum sequence. The cubes are all in different colors and the side where the sensor is attached is painted white to give a cohesive feel for what side of the cube should face the light. To control the drums the user must move the cube towards the light to start the part of the beat of interest. Depending on the distance from the light the drum plays a different sound and thus the user can create intricate drum patterns of sound with just four cubes and four sounds on each cube.

The second system module is a sampler. The sampler consists of two cuboids containing RFID-cards for switching samples, and a receiver station for the RFID-cards where the cuboids can be placed. Each time the station reads a RFID-cards the randomizer switches to a different sample of A cappella or instrumental music depending on which cuboid is read by the station. The sampler consists of seven instrumental samples and three A cappella samples, together with a random selector for each. To make it more interesting the sampler chops up the clip playing and jumps in the time span and plays a part from the beginning and later maybe a part from the end and continues to do that in a random order.

The third module controls the speed of the drums and samples and thus controlling the pitch of the music, the faster music or samples are played the higher the pitch. This is maybe the easiest to understand as the feedback is almost instant and direct to the user, to perceive and react to. The ball is green with a Nintendo Wii-Mote placed inside and the pitch of the Wii-mote is tracked for the speed of the drums and samples.

THE PILOT USER STUDY

The pilot study was conducted with seven teachers from the institution of Media technology. There were five male and two female teachers participating.

The pilot user study was conducted to evaluate the existing prototype and to reveal problems that might exist with it. When the users felt that they were done with trying the prototype, a session of discussing how the prototype could be further developed and simplified for easier understanding of the interaction. The pilot user study showed some issues on the complexity of the prototype and with the perception of some tangibles were confusing due to their appearance. The issues discovered were discussed.

Fig 2. Sensor Components of Cubio.
The light sensitive cube (top). The ball with the Wii-mote and "stand" for placing the ball in a fixed position (middle). The RFID-cubes and receiver station where the cubes can be placed in (bottom).
with the participants and and we received feedback and suggestions for how they could be simplified.

ITERATION OF PROTOTYPE
The issues that were discussed were mainly the perceptions of some of the tangibles. The idea for changes were that the perceived interaction and inviter of behavior of these were to "drum" on them and the sensor placed in these tangibles did not support that functionality. The perception of "drumming" on them was because they were covered in soft styrofoam like material and reminisced of drum pads, instead they were the sensors for changing the samples. They were changed to two cubes with RFID tags and another cube where the RFID-cubes could be placed in. This solution was easier to understand and it appeared a lot clearer how it worked for the user. Also when the user placed one of the RFID-cubes next to its "station" two led lights were turned on to signal response to the user. The complexity of having four sounds on each cube for controlling the drums where also too complex. The users had difficulties hearing the change in sounds to feel that they got a concrete feedback. These drum cubes were changed so the sound intensity of the desired drum starts to rise when the light starts to hit the sensor sensitive to light and at a set distance from the light the sensor has reached max of that sound and when that threshold is reached the second sound starts to play. The participants in the pilot user study showed a lot of appreciation of the color scheme of Cubieo and it was described with words as "playful" and "inviting".

METHOD FOR USER STUDY
The user study aims to capture the users interaction patterns when interacting with the tangibles of the artifact, what patterns that might emerge when interacting with the tangibles in Cubieo.

The user studies were conducted at two occasions with students from the ICT, Media And Design program at Södertörns University, the total number of participants were 15 persons, ten of which were female, and five male. The user study was recorded on film to allow for further analysis of the material. The prototype was set up in a darkened room with a sound system connected to the computer.

When the users entered the room they only got to know that it was a musical installation and that there were no right or wrong how to interact with Cubieo.

Law [15] writes in the article "The Measurability and Predictability of User Experience" to define user experience and the feel a user might have about a artifact is hard to define due to the complexity of an artifact.

To measure an artifact can be a complex task due to the abstraction of what the user feels. Law [15] writes "...one may argue that basically everything can be measured, but some things may be more ‘measurable’ than the others; how to estimate the threshold of measurability remains unclear.”.

The approach to conduct the user tests as observations was decided due to the complexity of the artifact, and the fact that there is not a right or wrong way to interact with the Cubieo.

This approach to interaction can be difficult to measure as McGee [16] writes about task driven interaction. The complexity of the task can cause the completion rates of the tasks to be high and error rates low (or the other way around) so that the data from the user test is inconclusive. Cubieo aims more to create an interesting user experience than an effective interaction to create music.

The notion of usability of user experience causes the data to depend on the persuasiveness of the empirical studies and evidence from the user test of its worth [15].

As Fällman [7] writes " Mixing artifacts with people also brings the question of ’now’ into play. This is to say that while natural scientists develop instruments to be used in a lab setting, abstracting away much of the core of the real world, the design-oriented HCI researcher’s instruments become used by real people—which inevitably carry with them meanings, presumptions, cultural and societal values and beliefs, and so on.” Fällman [7] means that the outcome might be totally unexpected and as Gaver [11] writes one researcher might have one outcome and another researcher might have a totally different outcome that shows new knowledge.

METHOD CRITIC
The observations that were conducted can be criticized for not having a diverse enough user group and that it was conducted in an area accessible only for students from the institution of media technology. The observations were also conducted at a time when a lot of students had lectures to attend, so the ability to easily get students for the observation was further hampered.

However the observations were conducted in this area and time of day due to restrictions in access to technology needed for the artifact to properly work and give the right experience of musical expression. The technology needed was speakers and amplifiers to the computer to give the users a feel of the sound and also the possibility of darkening a room enough so the artifact would work properly. The need of a room with subtile lighting for the interaction could have been solved with infrared sensors instead of light sensitive ones, but due to time restriction and funding this was not possible to change, and the idea of a darkroom was also a part of the concept.

One thing a majority of the users felt was a feeling that in some way their intelligence was evaluated. However this is not at all what was done, this was problematic though as it led to a sense of restriction affecting the creativity in a negative way.
Other parts of the user test that could have been done differently is that the camera was placed at a position where the users sometimes got in the way so only the back of the user were seen. This could have been solved if the had camera been placed in the ceiling instead of on a tripod. However it was not possible to attach the camera to the ceiling.

Zimmerman [24] suggests to approach problems in design research in the field of HCI. This calls for methods unique to the design and design process.

The model stems from Alexander’s [1] pattern language and builds a method for inquiry to address problems within HCI. The model consists of four so called lenses to evaluate design research:

1. **Process:** Evaluate the methods used during the process and provide arguments for why these methods were used. Document the process in enough detail so the process can be reproduced. Even though Zimmerman [24] acknowledges the fact Gaver [11] makes that the same results will not be reproduced.

2. **Invention:** The research must contribute with a significant invention.

3. **Relevance:** The benchmark for good research is its relevance. The research should motivate the benefits of the design attempts and why the community should consider this relevant.

4. **Extensibility:** The ability to build on the results of the outcome of the interaction design research. Either by employing the process for a future design problem or understanding the knowledge from the resulting artifacts. The process should be documented in a way that the community could understand the benefits of the result of the research.

In the light of Zimmermans model for evaluating design research the Cubieo project is a well documented process and could be reproduced. However as both Gaver and Zimmerman [11, 24] acknowledges the fact that the same results is hard to reproduce, especially when it concerns feelings from the users and thus is subjective. This may make the project perceived as less valid.

The Invention specific project refers to the tangible qualities of the Cubieo artifact which facilitates light and abstract tangibles for interaction with music.

Cubieo is an artifact which lacks a physical or digital counterpart and it exists as is. This makes the relevance hard to state as there is no ability to make a comparison. Through the idea of abstract tangible interaction can be an idea for further research and exploration.

The ability to build on the outcome from this study. The community can benefit from the ideas of abstraction and how this can further develop the user experience in forms of abstraction for tangible interfaces as well as for graphical interfaces.

This can evolve the user experience to a higher level and give the users a better experience in the right context of usage.

**USER STUDY RESULTS**

The general start for all the participants was that they felt unsure of what they were supposed to do. But after a few minutes they became more confident and they started to explore the installation and realize how it worked.

The exploratory state of the user lasted from just about one minute to several minutes. When the users started to realize how Cubieo worked some kind of “music” started to appear.

However, depending of the patience and the curiosity of the intended user this either was where he or she stopped to use Cubieo or started to understand more of the artifact.

The user study showed some interesting interaction patterns of the interactive properties of the TUI. It showed a vast variety of interaction styles and how it was explored from different users.

One group of students tried to dissect how the artifact worked, and this resulted in one of the students removing the Nintendo Wii-mote from the rubber foam ball.

Four other students methodically tried what each cube did and how they influenced the sound. Generally there was a lot of different ways of exploring how the artifact worked, from stacking cubes on top of each other to seeing if the same colored sides were affected if they were put together, or if the rubber ball influenced the sound if placed on a cube.

The general perception of the user studies was that the prototype was complex at the start but it became clearer after some time. These complexity issues was a problem of the TUI but not only, the user needs a curious personality to be truly willing to explore the prototype [6].

Other interesting patterns were how the users had the perception of relationship between the tangibles, the question here is why did they think that the tangibles had a relationship. Possible due to the shapes of the tangibles, that they were in approximately the same size and shape, and had an internal relationship of controlling the output. Only one part of the TUI had a relationship that was tangible-to-tangible, the other tangibles had a relationship of tangible-to-light and tangible-to-motion.

However as said earlier this relationship seemed not to be that clear, this probably has to do with the perceived affordances of the objects, that cubes should go with cubes and have a relationship to each other and to set the perception of relations between objects this must be described as a shape to shape similarity for the user. This also describes why the light interactive properties of the TUI seemed to be hard to grasp for some of the users.
We have to keep in mind that the level of abstraction in the TUI, because of this the explanation and similarities of the artifacts are on purpose.

The light properties were only described with a white side on the cubes as described earlier, if the purpose had been to make an easy to understand interactive experience, the best way of this had probably been to have some kind of circles with different colors depending on distance to the light. Also putting arrows or maybe some pictograms on the different tangibles for describing the purpose of each one. But this idea would have worked against the concept of Cubieo’s abstract properties.

**SUMMARY OF USER STUDY**

With the exploratory approach of Cubieo we wanted to support the users curiosity and sense of fun for the exploration of the artifact, as Djajadiningrat et al. [6] write that there is a threshold where interaction can not be too easy. If the interaction is too easy the user will quickly be bored and feel that the point of the artifact is lost.

Different interaction patterns that were clear were that the more instant feedback the installation had, the more engaging it were. This was not consistent for all of the users. The difference in interaction patterns came where some users started to interact to the beat of the drums and changing the samples accordingly and on beat, the same thing with the controls for the drums, some users started to play their own quite complicated music with the different tangibles in there hands and other placed at different distances from the light.

There was a difference between users who had a previous musical experience, such as playing an instrument. The users with a music background and interest of music seemed to understand the installation quicker and how it was to be controlled. But there is little fact to back that up, due to the fact that only a handful of users had a musical background of an instrument.

However many users seemed to have an idea at the start that the light was not the primary source for interaction, but the relationship between the cubes. This is an interesting idea and meaning of interaction that emerged.

But when the users realized that the white side of the cube was supposed to be aimed at the light bulb the connection of a relationship between the cubes seemed to be lost and just the light bulb become the point of interest for interaction.

The general feel and what most of the installation was that it was complex at start but, after some time the principle of how to interact with Cubieo became clearer and easier.

As a tangible user interface or TUI the installation worked good, however as some users pointed out, and what was also discussed in the pilot user study, was that visual feedback would have gained the users understanding of their actions as the visual feedback had provided instant feel of response. This idea was only used on the RFID receiver station when a RFID card triggered a reading, however it showed that it was a good idea and all the users understood the principle when the LED-lights were activated.

To summarize some interaction patterns:

- The abstract levels of the prototype was hard to understand for some users. This often had to do with the users curiosity and patience.
- Users often had problems knowing were the point of interest and connecting the light as a source of interaction. Although the cubes had one side that was in the same color this seemed not to help some users, a pictogram might have worked better.
- Some users wanted better explanation of the prototype, that often was a concern of "doing wrong".
- Further visualization probably would have helped users in their understanding, their bias and action, in relation to interaction and how it effected the music.
- The wires connected to the cubes were in the way for moving around the cubes.
- The more direct the feedback is, the easier the user will understand the controller.
- One interaction pattern of the users was that the tangibles with the same shape and size had affective relationship.

**DISCUSSION**

With Cubieo, the implementation of light based interaction shows that it works. But also the conclusion is that light as a source of interaction might not be the best alternative as it constraints the location of where the artifact can be placed.

As Djajandiningrat et. al. [5] describes that our bodily movement and perception of physical space plays a role in the design of interactive products. Also performing bodily movement affects the user as how the physical world is perceived and the physical appearance of the artifact alludes the users motor memory.

The idea of abstraction in interaction design, as emphasis on an unexplained tangible interface only works in chosen contexts. This idea works well as an abstract way of interacting with tangibles for a music experience.

The tangibles and the interaction capabilities they create simplified the internal complexity of the system and is thus simplifying the system [13].

The visualization through the tangible of the interaction and how the manipulation of the objects gave the user a graspable sense of what each interaction did as of manipulating the sound [22].
The abstract part of the project proved how tangibles visualize the information and help the users cognitive abilities of breaking down the artifact and solving how to interact with the artifact [22]. As Ullmer and Ishii [22] describe, visualizing abstract information such as numbers to a visual interaction helps the user in a cognitive way to understand how the artifact works. This notion is also applicable for Cubieo as demonstrated through the user study.

However the users had some problems in understanding the relationship between the tangibles. This could be simplified and explained with simple pictograms next to the installation or small pictograms on the tangibles. For instance a light bulb on the light sensitive cubes to suggest the related source of interaction. But this may be not desirable as that the artifact emphasizes abstraction, and the pictograms would work against that part of the conceptualization of the artifact.

CONCLUSION
The implementation of the artifact as an installation proved itself as an exploratory artifact for interaction with music. The idea behind a tangible musical interface as an installation both works for the aesthetic value of the artifact, but also the sense of a graspable interface where the user hears how the data is manipulated in real time and that the users movements of the tangibles manipulate the sound.

To claim that the artifact works depends on how you define the artifact working. This definition can either consist of the users creating some form of musical feedback, or understanding the function of all the tangibles and their intertwining relationship with each other, which makes it scientifically difficult to measure. It all stems from the users perception of use.

The user study confirmed the premise that the tangibles have a richer affordances as physical handlers [7] and were engaging for the users of Cubieo.

The artifact supports several users and in multi-user contexts the interaction also becomes a way for the people using the artifact to connect to each other as Van Boerdonk et. al. [21] present in the paper "Contact through canvas: an entertaining encounter" we can also conclude that the music both works as an icebreaker for people and is something they can relate to in one way or an other.

The result of the user studies different outcomes depending on the person(s) using it. To some extent these results have to do with prior musical knowledge but also the different backgrounds of the persons [10].

As Paradiso writes to give better feedback of the interaction is light used as a medium to communicate an event [18]. This could be utilized further in Cubieo and would have nurtured the users cognitive thinking [22].

To conclude a definite outcome is hard, due to the perspective of the artifact, not having an absolute way of working [12, 13]. As both Zimmerman and Gaver [11, 24] write the outcome from a research can not always be reproduced in the same way due to different variables.

The notion of visualization of data is one that the reacTable [14] is utilizing for the clarification of data displayed on the reacTable. This is also supported by Ullmer and Ishii [19, 9] who write that a visual feedback helps the user to understand and the tangibles help the users cognitive level of understanding.

The less clearly utilitarian approach to the artifact engaged the playfulness of the users [10].

Some general conclusions can be made from the user study, one is that the abstraction and generalizing of a tangible interface can be engaging and fun in an meaningful way for the user.

Some users had the perception that some of the tangibles had a relationship and thus tried to find how they related each other.

The idea of an abstract tangible interface works as its best when the user does not have a specific idea of what kind of feedback to expect. This works good when the relation between tangibles are loosely defined and left to the user to explore.

REFERENCES


