

DESIGNING INTERACTIVE TOUCH-
BASED MUSICAL INSTALLATIONS

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree. I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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i. Abstract

This thesis presents practice-based research regarding the creation of *The Plants*, an interactive touch-based musical installation. Participants interact with a large scale 'instrument' that is activated when a participant's skin touches living plants. A pilot study examining participants' experiences of the interactive exhibition *In Touch* is also discussed. This research was conducted 'in the wild' as part of public installations.

In Touch and *The Plants* utilise capacitive touch sensors to trigger sounds stored on microcontrollers (Arduino etc.) or single board computers (Raspberry Pi). Two distinct sensors were used as the point of contact for the audience namely conductive paint (*In Touch*) and various plants (*The Plants*). This technology has been outlined in relation to the primary focus of this paper which is the discussion of audience participation and engagement.

Most research in this field is concerned with works for adults, this thesis argues that it is important to design work that considers children as engaged, active participants.

The audience studies described in this thesis led to a series of findings examining participants' experiences with the artworks. These include a common journey from observer to active participant. This concept has been investigated, and an engagement model has been outlined to illustrate this journey. Distinct modes of interaction have been outlined which include 'solo play' and 'collaborative play'. Within these modes participants engage in a variety of activities outlined in an engagement model. A series of design criteria related to this engagement model has been presented. Finally, these design criteria have been used to evaluate new works by the author.

Keywords: Interactive, Musical, Installation, Children

Stakeholders: Interaction Designers, Researchers, Artists.

1. Introduction

1.1 Introduction

This research project follows the process of designing, developing, producing, installing and facilitating two new interactive touch-based musical installations. These works are:

- *In Touch*, an interactive touch-based musical installation that invites participants to create music and trigger sound effects by touching paintings on a gallery wall. This exhibition was installed in a public gallery for one month. This work will serve as a pilot study. Observations from participant surveys will inform a set of preliminary design criteria used to evaluate the next work described.
- *The Plants*, an interactive touch-based musical installation that turns plants into triggers for sounds. Three banks of sounds were experimented with: a piano, a synthesizer, and bird sound effects. This work was presented to the public over two days.

The aim of this research project is to create a set of design criteria which can be used to aid the development of effective and engaging interactive artworks. Both research and practice will inform the design criteria. Multiple research methods have been employed:

- A participant survey for pilot study *In Touch*.
- Analysis of video documentation of *The Plants*.
- Collaborator interviews that examine both works.
- Observations of user interactions captured in field notes and recordings of *The Plants*.

The central questions that I hope to answer from the data collected are:

- How do people interact with the installations?

- What are the design criteria that will help improve the engagement, interaction and collaboration in future iterations of these works?

The final outcome of this research project is:

1. The creation of two new interactive touch-based musical installations.
2. Identification of participants' modes of interaction with the artworks and a model of engagement.
3. A set of design criteria to aid further exploration in this field.

I will be describing observations that I deem as significant and acknowledge that this is a subjective exercise. What is interesting or significant to me may not be noteworthy to anybody else. I hope to develop design criteria that can be utilised as a whole or in part, or simply serve as a basis for further study.

The age range of participants that engaged with these installations was broad (approximately 1 – 80 years). The works herein were designed to appeal to any age with a particular focus on creating engaging interactive works for children. The original focus of this research project was on participants aged 2 – 12. This focus had to be broadened as it became evident that children's interaction with the works is inextricably linked to the experiences of participants of all ages. This practice-based research thesis will give an insight into the creation of interactive touch-based musical installations for both children and adults.

1.2 Background

I have been creating theatrical and musical works professionally since 2004. In the last five years, I have been increasingly interested in the intersection of art and technology. I am particularly passionate about creating environments that give participants agency, a place where they can create and collaborate. I have been influenced by the work of *Polyglot Theatre*, Australia's leading creator of interactive and participatory theatre for children and families. I have worked at *Polyglot Theatre* as a collaborator and performer since 2010. I have been directed by and collaborated with *Polyglot Theatre's* artistic director Sue Giles. Sue has shown me

the importance of developing work that empowers the participant and creates a place for exploration and play.

In February 2014, I purchased the *Korg WAVEDRUM Mini*,¹ a drum pad that came with a small clip which could be attached to any object, transforming it into a velocity sensitive trigger. This device introduced me to the idea of using technology to transform everyday objects into a musical interface. The *YouTube* video of a banana piano² ([Gomes 2013](#)) also demonstrated this abstract idea well. I purchased an *Arduino* and began to experiment with interactive musical interfaces such as the 'sound desk' for *Polyglot Theatre's Paper Planet*, *Musical Chairs* by *Invisible Orchestra* and my digital arts company *Playable Streets* (these works are discussed more in chapter three: Foundation Work).

In March 2016, I created my first interactive touch-based musical installation, comprising of activated musical plants and street furniture on Swanston Street in Melbourne. The experiment was a proof of concept and a test for the technology. We discovered many problems with the technology. Only four of the planned thirty-six contacts worked, four lonely plants rigged up to trigger sounds when they were touched. Fortunately, those four plants were enough to get people playing and collaborating, encouraging us to continue our experiments.

In April 2016, together with composer Cayn Borthwick, engineer Michael Henning and illustrator Edwina Atkins I set about developing the first work in this study: *In Touch*. The aim of this work was to create a space that was welcoming and encouraged play and collaboration. The response to the work was very positive. Anecdotally, the public engagement was the highest that the gallery had ever witnessed. Over the last weekend of the installation, I asked participants to fill out surveys of their experience (discussed in chapter five).

With the many lessons learnt from *In Touch*, Cayn, Michael and I collaborated again on the interactive touch-based musical Installation, *The Plants*. We developed the

¹ <https://www.youtube.com/watch?v=DXUaeuVmypo>

² <https://www.youtube.com/watch?v=rfQqh7iCcOU&t=8s>

work during a one-week intensive residency at the Abbotsford Convent studios. Over two days we presented the work outside, on a busy pathway at the Abbotsford Convent.

I hope that this study can contribute to my future work and the work of researchers and practitioners in this field.

1.3 What Are Interactive Touch-Based Musical Installations?

I have developed the term ‘interactive touch-based musical installations’ as I feel that it best describes the works discussed in this thesis. To clarify this definition, I will outline the term in its separate parts:

Interactive

“Interactivity is a complex phenomenon”(Joseph 2012). There are many ways to discuss interactions within interactive artworks. I will discuss this in more depth in my literature review. I will briefly explain here ‘performative interactions’ as it is a fitting concept in relation to this research.

‘Performative interactions’ are divided into two modes by Williamson et al. (2014). First, the interaction between performer and interactive technology used as a performance tool - for example, a stage presentation by Imogen Heap with her MiMu Gloves³ in which she creates music by moving her hands through the air. The second mode consists of spectators connecting directly with interactive technologies in public environments. Within this mode, the term ‘performative’ denotes the bodily or verbal conduct of a participant reacting to the technology used. It is this second mode that I believe applies to the interactive touch-based musical installations discussed in this thesis.

³ <https://www.youtube.com/watch?v=7oeEQhOmGpg>

Examples of this performative interaction mode in practice include works such as *The Pool* by Jen Lewin Studio,⁴ *Cloud* by Caitlind R.C. Brown and Wayne Garrett,⁵ or *Shadowing* by Chomko and Rosier,⁶ all utilising embedded technologies to translate a participant's actions into the artwork that is viewed by participants and spectators alike.

This idea of performative interactions suggests a transformation that occurs when the public steps over the invisible line between observer and participant. I am hoping to create works that facilitate that transformation. Bilda et al sum it up well: "within an interactive art system, the audience as well as the artist, is engaged in a creative pursuit." (2008). Motivating the audience to engage is therefore a key challenge for artists working in this domain.

Touch-Based

Capacitive touch is the method of triggering sounds within these works and differentiates participants' interaction from gesture-based interfaces using motion tracking or accelerometer technologies. Within the works discussed here the interface that participants interact with can take many forms. The interface is essentially an 'instrument' with sensors that send a signal to a computer to trigger a sound. The installation *In Touch* utilised conductive paint on the walls as the sensor; in *The Plants* the sensors were various living plants. The way that sounds are triggered and the 'instruments' are played is through contact from the skin. The small electrical charge inside our bodies is detected by the sensor (i.e. paint or plant) and triggers a microcomputer to play a sound sample or MIDI note. This is achieved by using capacitive sensors described in chapter five. Any bare skin can activate the sounds but hands are most commonly used. I was drawn to create musical installations that are activated by touch because I am interested in creating works that rely on technologies that don't involve a screen. I believe that skin-based musical interfaces are an interesting field of study that offers many possibilities for further exploration.

⁴ <http://jenlewinstudio.com/the-pool>

⁵ <https://incandescentcloud.com/aboutcloud/>

⁶ <https://www.playablecity.com/projects/shadowing/>

Musical

These works are defined as musical as they allow participants to create music in real time from prerecorded musical notes, riffs, and sound effects. John Cage asserted that “Everything we do is music” ([Kostelanetz 2003](#)) which illustrates the broad scope for defining an installation as ‘musical’. These works require little need for virtuosity to create a musical composition, one simply needs to reach out and touch an object. Participants create musical soundscapes that could fit into the genre of minimalist music reminiscent of *Klavierstück V* by Karlheinz Stockhausen or composers such as La Monte Young, Steve Reich and Phillip Glass.

Installation

These works could be seen as ‘public art’ or even an ‘art intervention’ but I have decided on the term Installation as it evokes a site-specific work that transforms people’s perception of a space. These installations can exist either indoors or outside and their main goal is to subvert the perceived function of familiar objects (i.e. paint or plant as a musical interface).

1.4 Significance of the Research

This research is significant because of the explosion of interest in technology-driven interactive artworks, particularly those which aim to engage children. Works that exemplify this growing field are public installations such as *21 balanoires (21 swings)* by *Daily tous les jours*⁷, *Press Play* by *Toca Ai*⁸ and *Sound of Drawing* by *Polyglot Theatre*⁹. Companies such as *Polyglot Theatre*, *The Urban Conga*, *Contact Theatre*, *Stalker*, *ENESS* and *TeamLab* are exploring new ways of engaging children with technology-enhanced theatre and public artworks. These works are transforming public spaces such as city streets¹⁰, children’s hospitals¹¹ and more traditional

⁷ <https://vimeo.com/40980676>

⁸ <https://vimeo.com/92920588>

⁹ <https://www.youtube.com/watch?v=fQIN8IEF0v4>

¹⁰ <https://www.playablecity.com/projects/hello-lamp-post/>

¹¹ <https://www.archdaily.com/802196/translucent-wood-and-light-installation-brightens-childrens-hospital-in-australia>

venues such as art galleries¹² and museums¹³. Groups such as *Playable City* are creating international networks that are actively using technology to transform our future city through interactive art.

This interest in interactive experiences for children is not reflected in academic study. Addressi et al. (2005) note that research on the relationship between children and technology is grossly under-represented. The research by Child Computer Interaction Group (Chi CI) (Read et al. 2006) is trying to address this gap, focusing on computer interactions and design with children (Horton et al. 2012). The move towards STEAM (Science, Technology, Engineering, the Arts and Mathematics) in education highlights the exciting possibilities for co-design of technology-driven art with children. This is demonstrated in the successful *STEAMPunk Girls* program developed by UTS¹⁴ (Saddiqui & Marcus 2017).

Stalker Theatre's Creature (Bluff & Johnston 2017) is an interactive mixed media 'play space' for children based on Ethel C. Pedley's *Dot and the Kangaroo*. Bluff and Johnston point out that many interactive works cater to one or two participants which may hinder social interaction (*Creature* can cater to 90 participants at a time). This illustrates the need for more research of interactive artworks that invite multiple participants to engage with a work simultaneously. Spence et al. suggest there is an 'almost untapped body of research that addresses interactions between two or more groups or individuals.' (2013). The installations discussed in this research project present simultaneous interactions between large groups of people. These studies are 'in vivo' or 'in the wild studies'. Linda Candy argues that it is import to study 'not only the user interactions with the creative system, but the social behaviour shaped by the scenario created'(2014).

Interactive musical interfaces are well represented in New Interfaces for Musical Expression (NIME) research but there is a lack of research in the way that children interact with these interfaces. There is also a lack of research on collaborative music systems, especially those with a novel interface (i.e. not based on a screen as an

¹² <http://www.polyglot.org.au/workshops/sound-of-drawing/>

¹³ <https://museums victoria.com.au/melbournmuseum/whats-on/childrens-gallery/>

¹⁴ <https://www.teachermagazine.com.au/articles/steam-education-taking-a-co-design-approach>

interface). The multitude of touch-based musical experiments online shows that there is a massive interest in creating novel musical interfaces but research does not match this growing interest. Some studies that explore touch-based musical interfaces are discussed in section 2.3.

My literature review has exposed a gap in the research of interactive touch-based musical installations, 'in the wild' research and installations that consider children as active participants. This gap highlights the importance of further research in this field.

1.5 Thesis Structure

Chapter two (Literature Review) will discuss design criteria and frameworks for creating interactive art. This review will guide the design criteria that will be formed in this thesis. I will consider the fields of capacitive touch interfaces, interactive installations and collaborative musical interfaces. I will also look at relevant artistic works within these fields that have influenced this research project.

Chapter three (Foundation Work) will outline relevant experiments, artistic works, and collaborations that have influenced the development of the two artworks documented in this thesis. This section will give an insight into the evolution of the technology and design of the installations studied here. It will also outline key findings from these works which will influence my preliminary design criteria.

In chapter four (Methodology) I will outline the research approach of grounded theory, constructionist grounded theory, and practice-based research. I will also describe my research methodology including participant surveys, video documentation, collaborator interview, field notes and audio recordings.

Chapter five (Interactive Touch-Based Musical Installations) describes in detail the stages of development and presentation of two interactive touch-based musical installations: *In Touch* (pilot study) and *The Plants* (primary study). In this chapter, I will present a summary of the technology, sound, and design of each work. I will also

discuss the results of the pilot study, *In Touch* and outline preliminary design criteria that influenced the creation of primary study, *The Plants*.

Chapter six (Observations) presents the findings from the primary study *The Plants*. An interview with composer Cayn Borthwick is presented and discussed as are field notes and audio recordings. The main source of data is four hours of video footage, and observations from this footage are described in detail. Finally, all of the observations are discussed and common themes are observed.

Chapter seven (A Design Framework for Interactive Touch-Based Musical Installations) presents an engagement model which demonstrates the observer to participant journey and modes of interaction including solo and collaborative play. Design criteria related to this engagement model is presented to aid in the development of future Interactive touch-based musical installations.

Chapter eight (Applications of Design Criteria and Future Work) suggests ways that these proposed design criteria could be employed to create new engaging works. I discuss how these design criteria have influenced new interactive works by *Playable Streets*. I also outline future research focusing on developing new works with children as design partners.

Chapter nine (Conclusion) is a summary of this design-based research project.

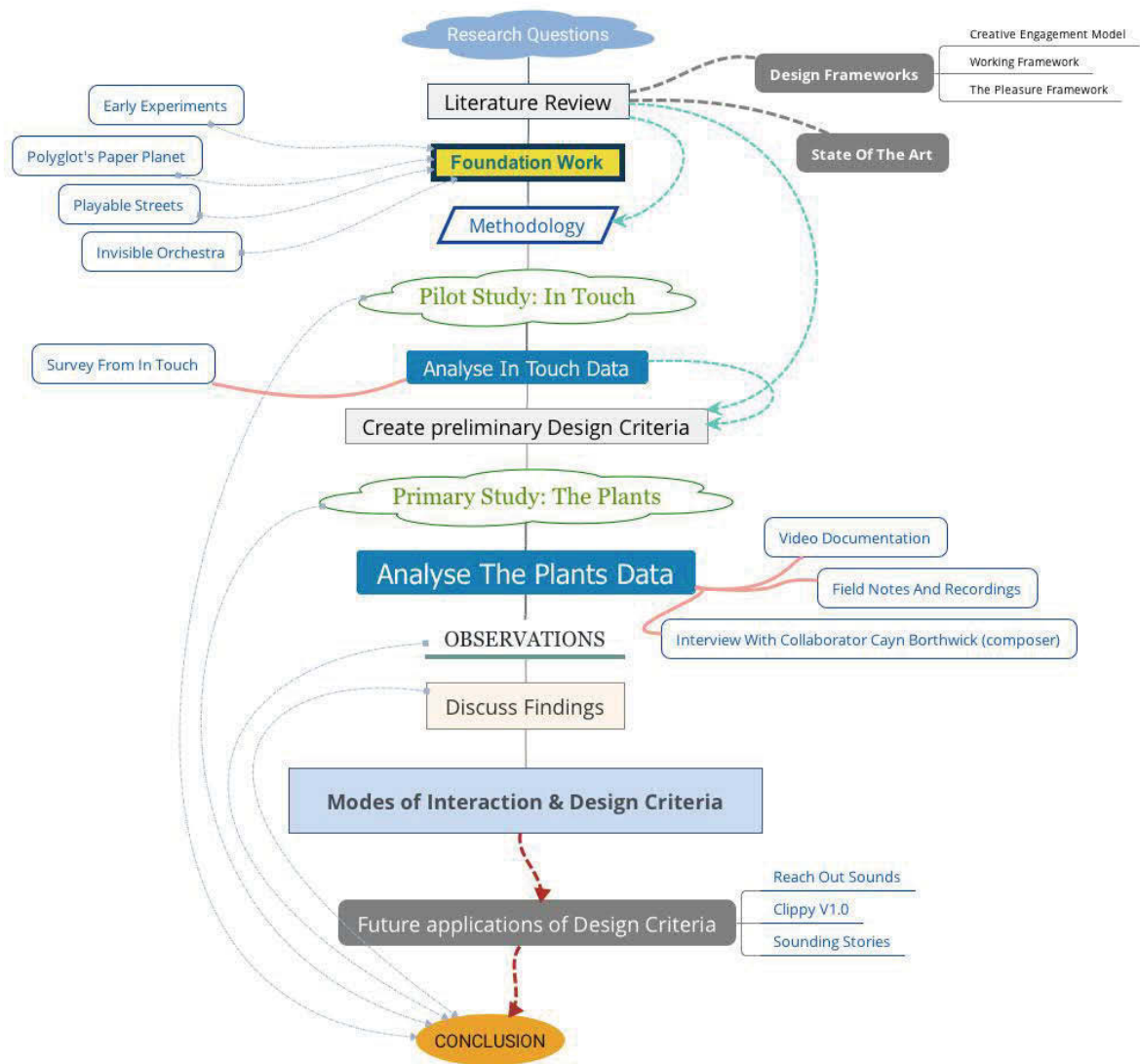


Figure 1 - An outline of the research project.

2. Literature Review

2.1 Introduction

In this chapter, I will outline the fields that have influenced the interactive touch-based musical installations discussed in this research project. This literature review is divided into four sections. I will first discuss three relevant frameworks and design criteria that have been developed within a digital art context.

Next, I will outline research and current trends in the fields of capacitive touch, musical interfaces and interactive installations. Relevant artworks will be discussed in each section creating a picture of current trends in these fields. This review will include some in-depth accounts of studies that are particularly relevant to this research project.

2.2 Frameworks and Design Criteria

Frameworks for designing interactive artworks can be gleaned from a broad range of fields such as computer games ([Malone 1982](#)), pedagogy ([Antle, Droumeva & Corness 2008](#)), interactive public performance ([Calvi 2013](#)), and musical instrument design ([Weinberg 2002](#)). I will be narrowing my focus to include three specific frameworks: the 'creative engagement model' ([Bilda, Edmonds & Candy 2008](#)), Costello and Edmond's 'pleasure framework' ([2007](#)), and Hall and Bannon's 'working framework' ([2005](#)). These frameworks include design criteria and modes of interaction based on the study of interactive art systems. I will also be referencing Edmonds, Muller and Connell's model of creative engagement which describes three specific attributes of creative engagement – 'attractors', 'sustainers' and 'relaters' ([2006](#)). This straightforward series of principles outlines the journey from observer to an active participant of an interactive artwork. 'Attractors' are the elements of a work that invites the public to engage with the work. 'Sustainers' keep the participant engaged while 'relaters' hold the attention and may encourage return engagements.

2.2.1 Creative Engagement Model

The 'Creative Engagement Model' ([Bilda, Edmonds & Candy 2008](#)) was developed to identify and improve collaboration between participants of interactive experiences. This model was borne out of research at the Creativity and Cognition Studios (CCS) observing interactive works presented at 'Beta Space' at the Powerhouse Museum, Sydney. Ten different works were studied between 2004 and 2007 using a variety of research methods such as observation, video-cued recall, interviews or questionnaires.

Five modes of interaction were identified:

- Unintended (the user is unaware of the controls of the work and interacts without specific intention).
- Deliberate (after the initial interaction the user has an expectation of how the work should react).
- Intended/ in control (the actions and the expectations of the user become aligned, they begin to understand the system)
- Intended/ uncertain (over time the 'dialogue' with the system shifts and layers of complexity are observed)
- Unexpected (in this mode the user starts to contemplate the experience deeper which "has the highest risk for frustration and the highest potential for creative outcomes and influential experience")

([Bilda, Edmonds & Candy 2008](#))

These modes of interaction are related to four 'interaction phases' that divide the interactive experience. These interaction phases overlap as they are dependent on the individual user's experience.

The interaction phases are:

- Adaptation
- Learning
- Anticipation
- Deeper Understanding

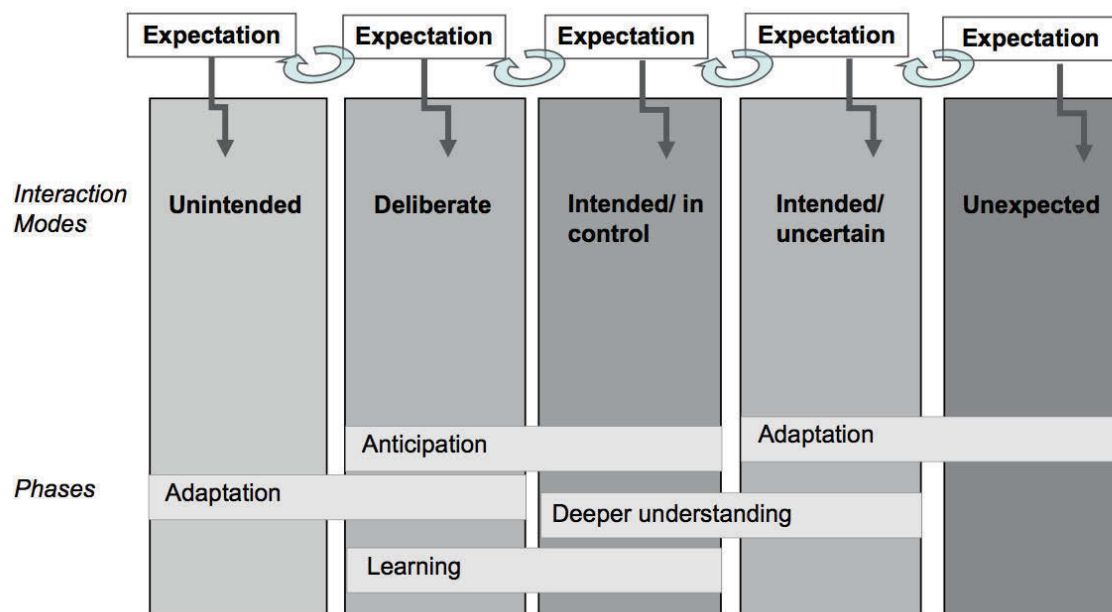


Figure 2 – The creative engagement model¹⁵

‘The most significant aspect of the model is that it suggests *sequential and temporal* definitions of experience’ (Bilda, Edmonds & Candy 2008). Each interaction could be different in terms of time and the journey that the participant takes within the interactive experience. The proposed engagement modes may not be followed to the end or could be in a different order. There also seemed to be a strong link between participants with artistic proclivities (such as a choreographer or musician) and a heightened engagement.

This study was carried out in a controlled environment with participants that knew well in advance that they were attending an arts experience. Therefore, it may be harder to apply this model to ‘in the wild’ experiences that may see different interaction modes.

2.2.2 The Pleasure Framework

The 13 pleasures of play in the pleasure framework (Costello & Edmonds 2007) was developed by assessing six theorists: philosophers Karl Groos and Roger Callois,

¹⁵ Reproduced from: Bilda, Z., Edmonds, E. & Candy, L. 2008, ‘Designing for creative engagement’, *Design Studies*, vol. 29, no. 6, p. 531.

psychologists Mihaly Csikszentmihalyi and Michael Apter and game designers Pierre Garneau and Marc LeBlanc. This framework was used to both develop and evaluate three interactive works by Costello (2007) at the Creativity and Cognition Studios *Elysian Fields*, *Sprung!* And *Just A bit of Spin*. The framework was a useful tool to evaluate these works and Edmonds concludes that the pleasure framework should be utilized for the evaluation of other interactive works and more general interaction design.

| <i>Groos</i> | <i>Callois</i> | <i>Csikszent'</i> | <i>Apter</i> | <i>Garneau</i> | <i>LeBlanc</i> | Framework |
|---------------------------|----------------|-------------------------|---------------------------------|---|----------------------|-------------------------------------|
| Pleasure of being a cause | | | | Power Creation | Expression | Creation |
| | | | Exploration | | | Exploration |
| | | Problem Solving | | Discovery Intellectual problem solving | Discovery | Discovery |
| | | | Challenge | Application of Skill | Challenge | Difficulty |
| | Competition | Competition | | Competition Advancement & Completion | | Competition |
| | Chance | Risk & Chance | Facing Danger | Thrill of Danger | | Danger |
| | Vertigo | | Immersion Beauty | Submission | | Captivation |
| Aesthetic sympathy | | | Arousing Stimulation | Physical Activity | Sensation | Sensation |
| | | | | | | Sympathy |
| Pleasure of make believe | Simulation | Creative | Fiction & Narrative | | Narrative Fantasy | Simulation Fantasy |
| | | Friendship & Relaxation | | Love Social Interaction | Fellowship | Camaraderie |
| | | | Negativism Cognitive Synergy | Comedy | | Subversion |
| | | | | | | |

Figure 3 - The theories that contributed to the pleasure framework¹⁶

From these 13 pleasures of play I will be focusing on four specific elements when creating my initial design criteria:

'Discovery is the pleasure participants get from making a discovery or working something out. For example, participants may be unsure about the

¹⁶ Reproduced from: Costello, B. & Edmonds, E. 2007, 'A study in play, pleasure and interaction design', paper presented to the *Proceedings of the 2007 conference on Designing pleasurable products and interfaces*, Helsinki, Finland.

relationship between their actions and a sound that a work emits and may then feel pleasure when they realize that a specific action can control that sound. The pleasure of discovery can also relate to the aesthetic elements in the work. For example, a particular action may provoke a different sound each time it is performed and participants may get pleasure from discovering a particularly pleasing sound.’ (2007, p. 80)

‘Sensation is the pleasure participants get from the feeling of any physical action the work evokes. For example, interacting with the work may require participants to wave their arms about in a way that is pleasurable or it may cause them to touch an object that has an enjoyable texture.’ (2007, p. 81)

‘Camaraderie is the pleasure of developing a sense of friendship, fellowship or intimacy with someone. This could be with another human participant or with a perceived entity within the work. A work could specifically require or encourage people to interact with each other or it might merely establish an environment that permits social interaction.’ (2007, p. 81)

‘Subversion is the pleasure of breaking rules or of seeing others break them. It is also the pleasure of subverting or twisting the meaning of something or of seeing someone else do so. For example, a work might require participants to behave in ways that would be frowned upon in real life and they might get pleasure from being so naughty. The content of a work might pleasurably subvert a meaning, thing, or relationship from real life. Participants might also feel subversive pleasure simply from behaving in ways that they perceive as being “against the rules” of the world set up by a work.’ (2007, p. 81)

It is important to note that the study of Costello’s interactive artworks was conducted in a controlled environment and participants experienced the artworks individually or in pairs. Also, more than half of the 15 participants in this study were considered ‘experts’. It will be interesting to see how this framework can apply to the works studied in this research project as they exist in a public setting with mostly non-expert participants.

2.2.3 Hall and Bannon's Working Framework

Hall and Bannon (2005) describe a study involving 'interactive techniques to stimulate active engagement and learning by children in a museum, through ubiquitous computer technology.' (2005, p. 62). I have included this framework because it is specifically designed with a focus on children's engagement. The work studied, *Re-Tracing the Past* was developed for a museum focusing on history and material culture.

Employing design-based research techniques Hall and Bannon developed this installation from a series of experiments and trials both in the lab and in museums. They also consulted children's history and museum education policy, museum experts and relevant literature. This holistic approach to the design of child-computer interaction was deemed successful and resulted in an engaging experience for the children.

Eight themes are described by which the work's success is ultimately tested:

- (1) Materiality (handling and tactual interaction are central in children's learning and meaning-making processes).
- (2) Narrativity (storytelling and narrative creation play a pivotal role in children's educational development).
- (3) Sociality (collaboration, between children and their significant others, is critically important in children's inter-subjective development).
- (4) Activity (children should be actively interpreting material culture for themselves, rather than passive and voiceless).
- (5) Multi-modality (the exhibition should support somatic learning: children need to engage with exhibits through their many senses: e.g., sound, touch, sight, smell).

- (6) Engagement (children should find the learning experience enjoyable and be motivated to participate).
- (7) Computer as augmentation tool (the technology should be easy-to-use and unobtrusive, effectively supporting collaboration and interaction).
- (8) Pedagogical activity (children should learn from the exhibition, evidence of learning will include: they correct misunderstandings; ask questions; and interpret and reflect on material culture).

([Hall & Bannon 2005](#))

This criterion was used as the evaluative framework for the *Re-Tracing the Past* installation. The results are summarized in their conference paper ([2005](#)) and outlined in full in the PhD ([Hall 2004](#)). *Re-Tracing the Past* is shown to be a success as it shows a high level of engagement in relation to the above design criteria.

The study stresses the importance of consultation with all stakeholders (including the children). It is also important that the physical environment is considered and curriculum requirements are met. This study offered 12 design guidelines or 'working framework' to be considered in future research:

- 1- Provides a narrative structure
- 2- The exhibition space is an inviting place.
- 3- Incorporates children's contributions.
- 4- Experience integrates computing.
- 5- Sustains children's curiosity.
- 6- Complements 'formal' history pedagogy.
- 7- Supports somatic learning (learning from all senses).
- 8- Facilitates both individual and group interaction.
- 9- Encourages discovery learning.
- 10-Supports different types of visits
- 11-Incorporates a variety of activities.
- 12-Timely and relevant intervention is provided.

([Hall & Bannon 2005](#)).

This design framework has a more pedagogical focus than the ‘creative engagement model’ or the ‘pleasure framework’ mentioned previously in this chapter. It has been developed specifically for creating computer-aided interactive environments for children.

2.3 Touch-Based

As Maria Montessori’s states “The hands are the instruments of man’s intelligence.” ([Elkind 2003](#)). The works that have been created for this research project are touch-based interfaces, triggered by the skin using capacitive touch sensors. Capacitive touch is the method of detecting touch using the capacitance of participants’ skin. This ‘touch-based’ interaction differentiates *In Touch* and *The Plants* from gesture-based interfaces using motion tracking or accelerometer technologies. Using the body’s capacitance for a musical interface has a long history such as the Theremin ([Leo 1928](#)), Michael Waisvisz’s *Crackle Box* in the 1970s ([Dykstra-Erickson & Arnowitz 2005](#)) or the *Otamatone*¹⁷ by Maywa Denki which uses a touch-sensitive ribbon controller to affect sound.

Broader non-musical applications of skin-based interfaces and skin-based input include: *Tactum*, an interface for manipulating 3D models ([Gannon, Grossman & Fitzmaurice 2015](#)); MIT’s *DuoSkin*, a temporary tattoo interface that allows the wearer to manipulate an app and communicate using NFC or display a wearer’s mood ([Kao et al. 2016](#)); and *Skinput*, a bio sensing arm band which allows the wearer to use their skin as an input surface ([Harrison, Tan & Morris 2010](#)). This research illustrates the exciting potential for the skin to be a dynamic user interface.

*Bare Conductive*¹⁸ is a company based in London that has developed conductive paint and hardware designed to allow artists to easily create works that incorporate capacitive touch sensing. Examples of this include *Trapped in Suburbia*’s sound

¹⁷ <http://www.otamatone.com/>

¹⁸ <https://www.bareconductive.com/>

poster experiments¹⁹, *The Urban Conga's Ambient Play*²⁰ or *Digital Dreams* by students from the *Savannah College of Art and Design*²¹ which includes a layer of mapped projection to add animation. *Bare Conductive* paint and hardware have also been utilised for creating touch-based instruments that allow participants with disabilities to engage in complex music making ([Atwell 2015](#)).

The abstract nature of touching a 'nonmusical' object and creating music is a very appealing concept demonstrated by the popular and numerous YouTube videos that use objects such as fruit²², water²³, foil²⁴ and Coke cans²⁵ to make music. The smartphone app connected vibration sensor *Mogees*²⁶ is another device that encourages people to turn inanimate objects into musical interfaces.

Touch and plants

Studies that focus on the skin as computer interfaces include Disney research lab's *Touché* ([Sato, Poupyrev & Harrison 2012](#)) which uses a 'swept frequency capacitive sensing' technique to recognize an initial touch event as well as the varying depth of contact. This technology is put into practice on plants in the research project 'Botanicus Interacticus' ([Poupyrev et al. 2012](#)). This study finds that different plants promote different interactions: 'an orchid invites users to slide fingers along its stem, while a gardenia suggests unstructured, playful interaction' ([Poupyrev et al. 2012](#)).

Using plants and other organic materials as interfaces within art installations have been explored to affect digital projections ([Sommerer & Mignonneau 1993](#)) and used to activate interactive musical soundscapes by art collective *Scenocosme* ([Lasserre 2015](#)).

¹⁹ <https://vimeo.com/224765580>

²⁰ <http://www.theurbanconga.com/ambient-play/>

²¹ <https://www.bareconductive.com/news/digital-dreams-in-physical-computing/>

²² <https://www.youtube.com/watch?v=yV7bJgudlQw>

²³ <https://www.youtube.com/watch?v=aXFBmunREuQ>

²⁴ <https://www.youtube.com/watch?v=rmmuEP1LkhM>

²⁵ <https://www.youtube.com/watch?v=Ttm62RBdOuo>

²⁶ https://www.youtube.com/watch?v=G_hBhORGE6Y

2.3.1 Skintemacy

Berlin University of the Art's Alexander Müller created *Skintemacy* (Müller, A. 2011). *Skintemacy*²⁷ is a device that uses the skin's natural low voltage transmission (galvanic skin response) to create data that provides values for sound mapping. *Skintemacy* offers an extra dimension of skin-based interaction as the sound produced is affected by the amount of skin to skin contact rather than simply triggering a single sound. The device works by connecting a sensor to the participant's skin which transmits a signal to an *Arduino* board. The *Arduino* unit sends information to *Pure Data*²⁸ which controls FM synthesis, playback rate, reverb, and balance.

Reliable control of the instrument is restricted by the many factors that impact the signal (i.e. moisture, pollution etc.) thus creating an instrument that has a broad scope for sound manipulation but little control and 'playability' (Müller-Rakow & Fuchs 2012). While still in the early stages of development, *Skintemacy* offers a glimpse into the future of skin as an interface for musical expression.

2.4 Musical Interfaces

For nearly 40 000 years humans have been connecting socially through the action of making music (Conard, Malina & Münzel 2009). The interfaces that we humans have utilised to make music have evolved alongside our technological advances. From bone flutes, Stradivarius strings, player-pianos, synthesizers to *Garage Band* on a smartphone there is an evident desire to find new and novel ways to make music. The International Computer Music Conference (ICMC), New Interfaces for Musical Expression (NIME), and Sound and Music Computing (SMC) are conferences that explore the new interfaces that we are creating to make music.

The prevalence of music making apps and games suggests that ways of playing and composing music are changing rapidly²⁹. Brian Eno's series of generative music

²⁷ <http://skintimacy.org>

²⁸ https://en.wikipedia.org/wiki/Pure_Data

²⁹ <https://roli.com/stories/future-of-mobile-music>

apps including *Bloom*³⁰ allows users to create complex ambient musical compositions by simply tapping their smartphone screen. Games such as *Guitar Hero*, *Rock Band*, and *Wii Music* demonstrate the popularity of combining music and HCI (Human-Computer Interaction).

A common theme of research that is concerned with the design of new digital musical interfaces is 'ease of use'. Most computer interfaces are made to be user-friendly or easy but in musical interfaces, it's much more complicated (McDermott et al. 2013). There is a tradeoff between ease of use and long-term engagement. The works discussed in this research paper are musical installations that are interacted with for relatively short periods (1 – 8 minutes). The ability to master these instruments over time is not available to participants. Also, making musical interfaces for children often means creating interfaces for a musical novice. Most 'Music Interaction' studies are concerned with creating interactive musical interfaces for professional performers and musicians. There is ample room for further research into the design of interactive music systems that have both a quick adaptation period and invite a sustained level of playability.

2.4.1 Polymetros

*Polymetros*³¹ is an interactive music system that encourages musical exploration and collaboration. Created for musical 'novices' it has been designed as both an audience experience and as a research tool to investigate interactivity. It consists of three or four *Novation Launchpad* devices connected to a computer running a software application written in *MAX*³². Participants create and control a repetitive musical phrase by pressing buttons on the interface. As the interfaces are linked each participants' musical contribution becomes part of the spontaneous collaborative composition.

Bengler and Bran-Kinns (2013) describe an approach to designing collaborative music experiences of *Polymetros* from a season at the Victoria and Albert Museum,

³⁰ <http://www.generativemusic.com/bloom.html>

³¹ Website for *Polymetros* with video demonstrating its operation:
<http://isam.eecs.qmul.ac.uk/projects/polymetros/polymetros.html>

³² <https://cycling74.com/products/max/>

UK. Influenced by Atau Tanaka's concept of the 'sense of musical agency' Bengler et al. design this collaborative musical experience that doesn't rely on pre-developed musical skills.

They identify an approach that many interactive systems use - pre-produced musical material that is controlled by participants. They discuss the limitations of this method such as participants having limited control over the musical output. Bengler and Bryan-Kinns stress the importance of creating a sense of musical agency. The system that they have created is connected to sophisticated software and hardware that allows for such musical creation and manipulation.

Polymetros seems to have been successful but it is clearly not for 'all ages' as the table that the device sits on is quite high (cancelling out interaction by younger participants). Also, because the device was built around an existing consumer device (*Novation Launchpad*) there was a lot of intuitive design already inherent in the work.

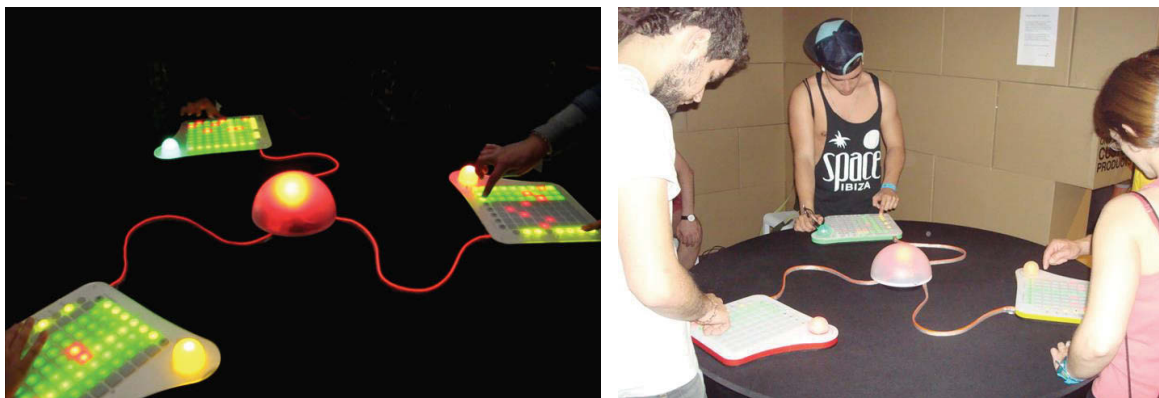


Figure 4 - *Polymetros* in action.³³

Based on 294 participants they observed an average 'dwell time' (active engagement with the instrument) of 3.3 minutes. They did not witness significant coordinated collaboration between participants which may indicate that the 'rules of musical collaboration' are not immediately adhered to by the musical 'novice'.

³³ Reproduced from: Bengler, B. & Bryan-Kinns, N. 2013, 'Designing collaborative musical experiences for broad audiences', paper presented to the *Proceedings of the 9th ACM Conference on Creativity & Cognition*, Sydney, Australia.

Another interesting finding was that participants who felt that another person was waiting to take a turn on the device were likely to stop playing.

This is discussed further in their follow up paper: “I could play here for hours...” (thinks the visitor and leaves) *Why People Disengage from Public Interactives* (Bengler & Bryan-Kinns 2015). They discuss Bollo and Pozzolo’s definition of ‘attraction power’ and ‘holding power’ (Bollo & Dal Pozzolo 2005) which is similar to the ‘attractors’, ‘sustainers’ and ‘relaters’ described by Edmonds et al. (2006). In this study, they found that ‘obligation to leave’ and ‘leaving by necessity’ (i.e. following friends) were the main factors that contributed to the length of engagement with this interactive work. Their findings suggest that scaling up the experience (i.e. having more interfaces that can be engaged with) would mitigate the social pressure of disengaging from the work to allow others to interact with it.

2.5 Interactive Installations

Technology has facilitated a massive leap in interactive experiences and novel interactive musical devices. Museums such as the Exploratorium³⁴ in San Francisco or the Museum of Applied Arts and Sciences (MAAS)³⁵ in Sydney are focusing almost entirely on interactive experiences to engage audiences of all ages.

New technologies being used in art is as inevitable as art itself (Candy & Ferguson 2014). HCI and Digital Art now coexist as artists find new ways to explore age-old concepts and themes using a plethora of new digital tools.

Participants of technology-based interactive artworks take on varied roles throughout an interactive experience. Researchers have several theories that define these ‘interaction modes’ including Calvi’s (2013) performance-based model of engagement (see figure 5) or Sheridan, Dix, Lock and Bayliss’ (2004) performance triad (see figure 6). These engagement models have all been created to study interactive experiences.

³⁴ <https://www.exploratorium.edu>

³⁵ <https://maas.museum>

Calvi's performance-based model was developed from observing interactive performance by Serbian artist Marina Abramović. This model of 'participatory engagement' breaks down engagement into five types: attract, sustain, threaten instrumental and functional. The engagement modalities (see figure 5) 'can be recognised in a sort of dialogue among spectators, between spectators and the performer or between spectators and a possible interface' (Calvi 2013). This is a preliminary model to design 'performative interactions' in public and semi-public spaces.

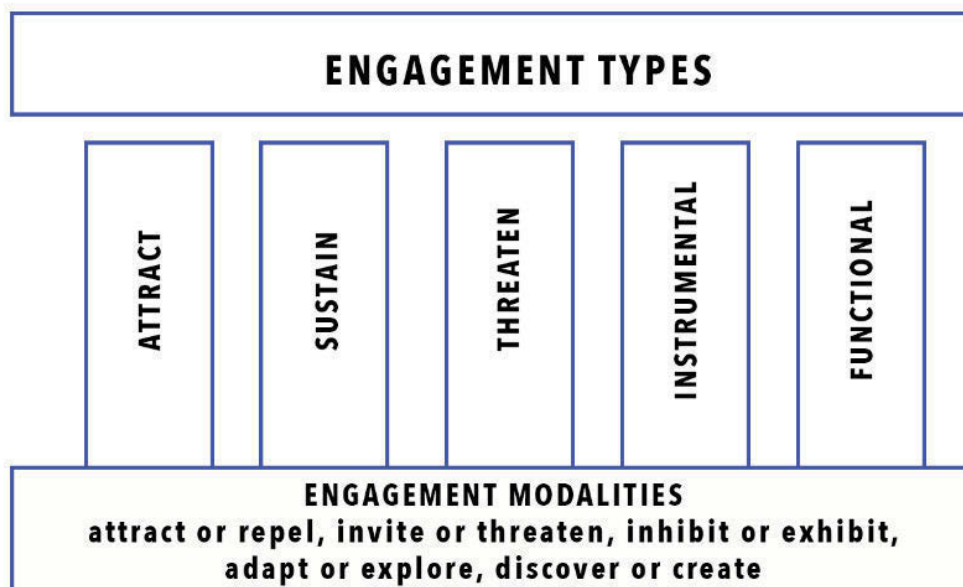


Figure 5 - Calvi's preliminary performance-based model.

With their 'performance triad' Sheridan et al. (2004) demonstrate the shifting roles that a spectator may embody, 'The observer, participant and performer are equal collaborators in a performance, which lies at the heart of the triad.' (Sheridan et al. 2004). Within this model, technology is a 'mediator' between participant, performer or observer and the 'performance'. This model also illustrates the importance of environmental and contextual factors on individual interaction experiences.

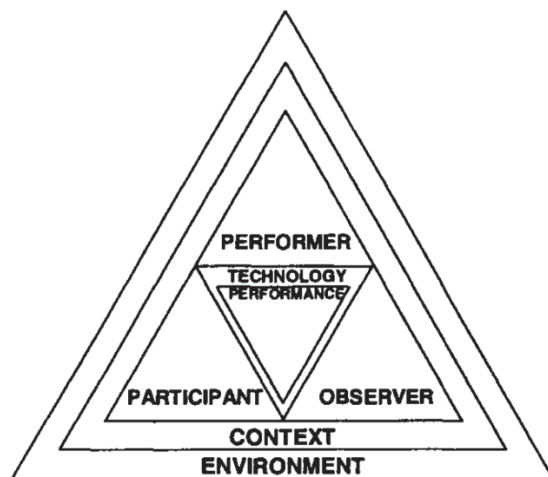


Figure 6 - Sheridan et al. performance triad.

These models see the participant in a constant state of flux, moving from one interaction mode to another over the duration of their experience. 'Audience experiences with interactive art-works develop through phases, each with its own characteristics and, hence, there is no simple single description of audience engagement.' (Edmonds, Bilda & Muller 2009).

Social embarrassment is a factor that deters public interaction within digital art systems. Brignull & Rogers (2003) identify a 'honey pot' effect which counters this embarrassment, drawing participants to a work if they see that it is already being engaged with. This research also suggests creating interactive spaces that allow people to 'be able to move seamlessly and comfortably between being an onlooker and a participant' (Brignull & Rogers 2003).

2.6 Conclusion

In this literature review, I have outlined design criteria which will guide the process of creating the two interactive touch-based musical installations discussed in this research project. These include 'The Creative Engagement Model' (Bilda, Edmonds & Candy 2008), 'The Pleasure Framework' (Costello & Edmonds 2007) and 'Hall and Bannon's Working Framework' (Hall & Bannon 2005).

I explored touch-based interfaces, musical interfaces, interactive installations, and discussed key creative works to illustrate the current state of the art. From this literature review, I have found that there are many frameworks regarding participant interaction although most of these were developed from lab studies rather than 'in the wild' studies. Furthermore, many studies are concerned with solo interactions rather than collaborative interactions. Often interaction studies are concerned with adult audiences rather than catering to 'all ages'. This is especially true in musical interface studies that are mostly geared towards interaction with musicians. I also found that the balance of complexity and simplicity within interaction design is a common challenge for designers.

This literature review has exposed a gap in the research of interactive touch-based musical installations. Specifically, there is a lack of research into real-world, collaborative, interactive arts experiences created with children participants in mind.

3. Foundation Work

In this chapter, I will discuss the experiments, theatrical works and collaborations that have influenced the development of the interactive touch-based musical installations that were created for this research project. I will also outline some of the main findings from these works which will influence my preliminary design criteria.

3.1 Early Touch-Based Technology Experiments.

In 2013 I found a video on YouTube, *the banana piano* ([Gomes 2013](#)) which led me down a 'YouTube hole' of creative and often bizarre musical interfaces. I was witnessing the phenomenon of the *Makey Makey* created by Bruno Zambourlin with the explicit intention to transform everyday objects into interfaces for controlling computers. I tried to find any video that was using touch sensitivity to make music. It was so simple, yet such an abstract notion, using organic materials, charcoal drawings, fruit or conductive paint to trigger sounds. I ordered a version of the *Makey Makey* board along with an *Arduino UNO* and began experimenting.

My experiments included creating musical interfaces with flowers, tin foil, lamps, food, and water. I began imagining outdoor installations that could transform any street into an interactive musical environment. My ambition was not in line with my technical abilities however so I began talking to engineers, composers, and designers to collaborate with.

3.2 Polyglot Theatre's Paper Planet

I have been working as a collaborator, designer, musician and performer for *Polyglot Theatre* since 2010. I have worked on their flagship interactive outdoor play spaces *We Built This City*, *Tangle* and *Paper Planet*. 'Polyglot's mission is to make innovative and daring theatre which provides children worldwide the opportunity for imagination and adventure through participation.' - Polyglot Mission Statement ([Polyglot 2015, p. 2](#)).

*Paper Planet*³⁶ consists of a forest of cardboard trees that become inhabited by the creation of children and their parents over the duration of a season (from one day to two weeks). The installation grows as participants build a wide variety of objects using simple materials such as paper, cardboard and masking tape. Participants of all ages are brought into this arts experience and invited to explore, discover and create.

As the *Paper Planet* musician, I created an evolving and spontaneous soundscape that reacts to the action in the space. In 2015 on a USA tour of *Paper Planet* I created an interactive sound desk that allowed children to contribute to the live soundtrack of the work by simply touching copper leaves. The conductive 'leaves' can be activated by participants to play along with the evolving soundscape. As participants used their touch to trigger notes I began to imagine the possibilities of creating digital instruments that can be played by participants of any ability level. This interactive sound element of *Paper Planet* has developed over various seasons.

I observed that musical interactions evolved from the simple tapping of the leaf triggers to people connecting each other's skin to trigger the sounds. Children would play their dad's nose as an instrument or give each other high fives to trigger sounds.

I have toured with this work across Australia, America, and China as the live soundtrack musician. I have become acutely aware of the spirit of musical curiosity

³⁶ <http://www.polyglot.org.au/performances/paper-planet/>

and experimentation in the children I have met. Witnessing the intensely inquisitive nature of children as they interact with sound and create music has drawn me to this stage in my arts practice and this research project.

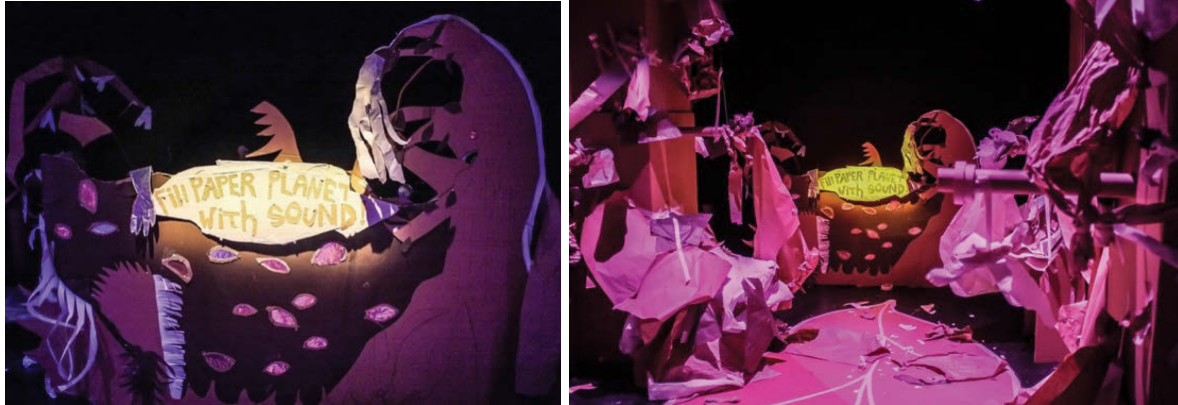


Figure 7 – Polyglot Theatre's Paper Planet.

3.3 Separation Street

Separation Street is a large-scale interactive work created in collaboration with *Polyglot Theatre* and *The Suitcase Royale* theatre company. As a member of *The Suitcase Royale*, I was involved in the development and performance of this work 2013 - 2015. Through a series of workshops and investigations with schools around Melbourne, *Separation Street* explores the theme of disconnection and isolation. The radical yet simple premise of the show revolves around the separation of the adults and the children at the beginning of the experience. The work tells the story of Frank, a misunderstood child that strives to follow a distress signal into the stars with the help of the audience. This is 'theatre simultaneously for adults and children that physically explores relationship and connection and serves to empower the child to lead the adult on a journey of social re-imagining.' (Adams 2014).

Separation Street demonstrates the possibilities for creating interactive theatrical experiences that engage audiences of all ages. Another noteworthy aspect of this work (and most of *Polyglot Theatre's* output) is that it does not have an educational imperative. The work is created the way that most theatre is created, exploring a theme or idea rather than educating the audience. This is an important and

potentially radical way of thinking in the creation of interactive theatrical experiences for children.

3.4 Musical Chairs by Invisible Orchestra

Musical Chairs by *Invisible Orchestra* (co-produced by *Polyglot Theatre*) has been created in collaboration with theatre maker Matt Kelly and composer/ engineer Andrew Callaghan. It is an interactive musical work for children that encourages participants to become musicians and composers. A reimagining of the ubiquitous childhood party game, *Musical Chairs* invites children (and their parents/ guardian) to sit, bounce and play on a series of up to 50 chairs. The chairs trigger sounds and instruments via *Arduino* programming, *Pure Data*, and *Ableton Live*. The emphasis of this work has been to create music that sounds beautiful while the participant maintains a sense of agency in the work, feeling like they are indeed interacting with a musical instrument. During the second development of this work, I developed a survey to gauge the response from the children present. This survey formed the basis of the one that was developed for the *In Touch* pilot study described in chapter five.



Figure 8 – *Musical Chairs* by *Invisible Orchestra*.

3.5 Playable Streets

At the beginning of 2016, I was commissioned to produce a work of public art for the city of Melbourne's 'Test Sites' initiative. I collaborated with engineer Michael Henning to develop an interactive touch-based musical installation that would activate a section of Swanston Street in the heart of Melbourne. The aim was to wire up objects on the street (metal rails, rubbish bin lids, metal benches, etc.) so that they would trigger sounds from modified *Arduino* units. The installation of the work was problematic and I discovered a lot of practical issues with the technology used. The elements that worked illustrated the engagement possibilities of the work as I observed participants playing with friends and strangers. This season for Test Sites was the first work for *Playable Streets* which is the company name under which I created the works discussed in this research project.

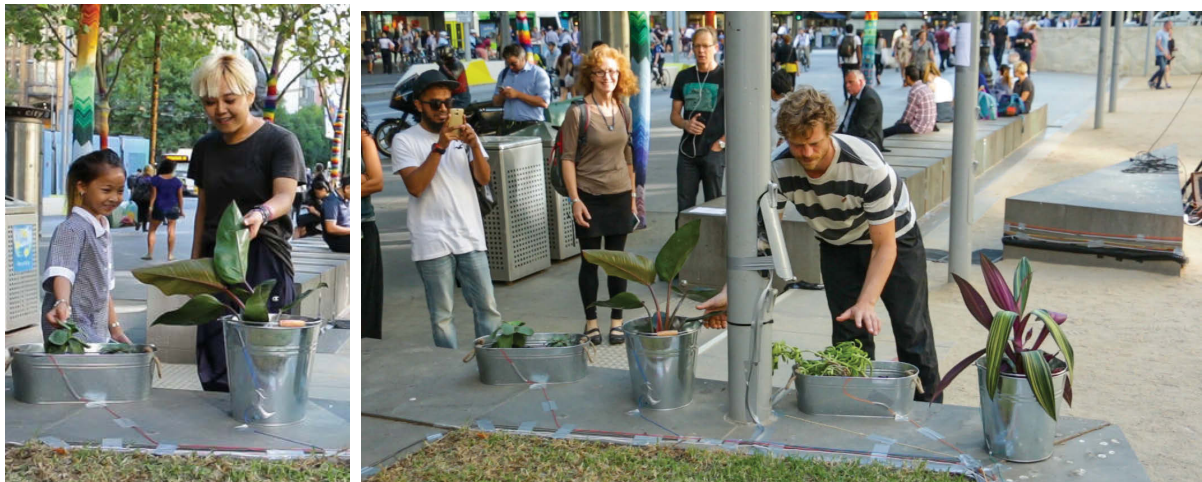


Figure 9 –*Playable Streets*' Test Sites season at City Square, Melbourne.

3.6 Conclusion

In this chapter, I have outlined the collaborations that have led me to develop two new works for this research project (and future works discussed in chapter eight). I have learnt a great deal through trial and error and collaborating with engineers, designers, composers, and performers.

The main findings I have discovered from experimentation and developing work with *Polyglot Theatre*, *Invisible Orchestra*, and *Playable Streets*:

- Collaborate with people instead of trying to figure out everything yourself.
- Be inspired by the creativity of children.
- Don't be too prescriptive, allow space for free play and for participants to use the work in new and unexpected ways.
- It is very important for participants to feel like they are controlling the sounds as they are triggered. This is achieved by having the sound source (speaker) as close to the player as possible.
- Don't be afraid of chaos.
- Leave as much time as possible for testing and where possible test in the environment that the installation will inhabit.

4. Methodology

4.1 Introduction

This practice-based research project's aim is to design and exhibit two interactive touch-based musical installations and examine participants' experiences and behaviours within these works. From the study of these works, a series of design criteria will be proposed. As this is practice-based research (Candy 2006) the artworks themselves form the basis of the research and inform the path that the research ultimately takes. As this is still a relatively new area of study I will be utilising methodologies previously used for the evaluation of interactive art.

'The evaluation of interactive art experience based upon evidence from research is not an area where there are settled methodologies that everyone has agreed and applied routinely.' (Candy & Ferguson 2014). I will be using a pluralistic approach relying on several sources of data:

- A participant survey (for the *In Touch* pilot study only).
- Interview with collaborator, composer Cayn Borthwick.
- 4 hours of video documentation of *The Plants*.
- My own field notes, recordings and memos.

In this chapter, I will discuss the research methods employed and show why they are relevant to this research project.

The research questions are:

- How do people interact with the installations?
- What are the design criteria that will help improve the engagement, interaction and collaboration in future iterations of these works?

This chapter will focus on:

- How, using constructionist grounded theory techniques, do I gather and analyse data by identifying and 'coding' the experiences of participants and collaborators from observations collected 'in the wild'?
- How do I use this data to gain an understanding of common themes and a relationship between modes of interaction and the design criteria?

4.2 Research Approach

4.2.1 Grounded Theory

As opposed to positivist research which is concerned with empirical and quantifiable observations ([Collins 2017](#)), grounded theory can begin with a collection of qualitative data that is reviewed and coded ([Glaser & Strauss 1967](#)). This coded data is in turn grouped into concepts (or themes) and categories. These categories will be used to develop a theory of how people interact and this informs the development of a set of design criteria. Grounded theory is often used in fields that are under-researched where there is little precedent or theories to compare to. As mentioned in the literature review there is little specific study of interactive touch-based musical installations which makes grounded theory research an appropriate method.

The design criteria presented at the end of this thesis hopefully answer these grounded theory questions:

1. Fit – does the theory fit the substantive area in which it will be used?
2. Understandable – will non-professionals working in the substantive area understand the theory?
3. General – does the theory apply to a wide range of daily situations in the substantive area?
4. Control – does the theory allow the user some control over the structure and process as they evolve?

([Glaser & Strauss 1967](#))

Coding

I will be using the grounded theory method of substantive coding used in many HCI studies, and in particular music interaction studies ([Xambó et al. 2013](#)). I will develop a coding system that is based on interactions observed in pilot study *In Touch*. This open coding method is an iterative procedure of labelling data to build a collection of observations that will form the basis of a set of design principles.

4.2.2 Constructionist Grounded Theory

Constructionist grounded theory is an updated version of the grounded theory method introduced by Glaser and Strauss in 1967, with an emphasis on reflection within the research process. It places the researcher, the research process and artwork in a cultural, social and interactive (between the data and the analysis) context. Importantly it also acknowledges the researcher's inherent subjectivity within the project. 'Constructionist grounded theorists attend to what and how questions. They emphasize abstract understanding.' ([Holstein & Gubrium 2013, p. 398](#))

Constructionist grounded theory allows for a symbiosis between art and research. This methodology is especially important when analysing works that rely on Human-Computer Interaction (HCI) as this field is somewhat split between the inherent subjectivity of art and the more rigid evaluation used for science and engineering ([Höök, Sengers & Andersson 2003](#)).

The role of the researcher as being involved directly with the outcome of the research is outlined in the Holstein and Gubrium's handbook of constructionist research:

- (1) Reality is multiple, processual, and constructed - but constructed under particular conditions;
- (2) The research process emerges from interaction;
- (3) It is taken into account the researcher's personality, as well as that of the research participants;

(4) The researcher and researched construct the data - data are a *product* of the research process, not simply observed objects of it'

([Holstein & Gubrium 2013, p. 402](#)).

As I am both the artist and researcher within this project it is important to understand that my observations are not unbiased. The Grounded Theory methods provide techniques that help reduce the effect of my biases. By applying these techniques to analyse the data, I will construct a set of design criteria that will be informed by the artworks and the research undertaken.

4.2.3 Practice-Based Research

This thesis will follow the guidelines set out in 'Practice-Based Research: A Guide' ([Candy 2006](#)). The research must address a series of questions that will be explored through the course of the study. It also needs to demonstrate the importance of the research, where it fits in the context of other research and what it offers to the field. Finally, practice-based research should outline the research methods used and demonstrate the reasons for using such methods.

The goal of practice-based research is to develop knowledge through the study of newly created artefacts. In this case specifically, it is the research undertaken on two new interactive artworks, *In Touch* and *The Plants*. These works will lead to a new understanding about interactive touch-based musical installations. The design criteria produced may also assist interaction designers more broadly. According to Candy and Edmonds 'The importance of practice-based research in advancing the field of interactive art is not widely understood.' ([2011](#)). This research project aims to demonstrate the importance of practice-based research in developing design criteria for interactive art.

Research Structure

As shown in figure 10 this is a cyclical research project which is constantly evaluating findings to enhance the design criteria and in turn, the artworks created.

Every iteration of the design criteria is applied to the next work created and then refined in relation to the participant's engagement with that work.

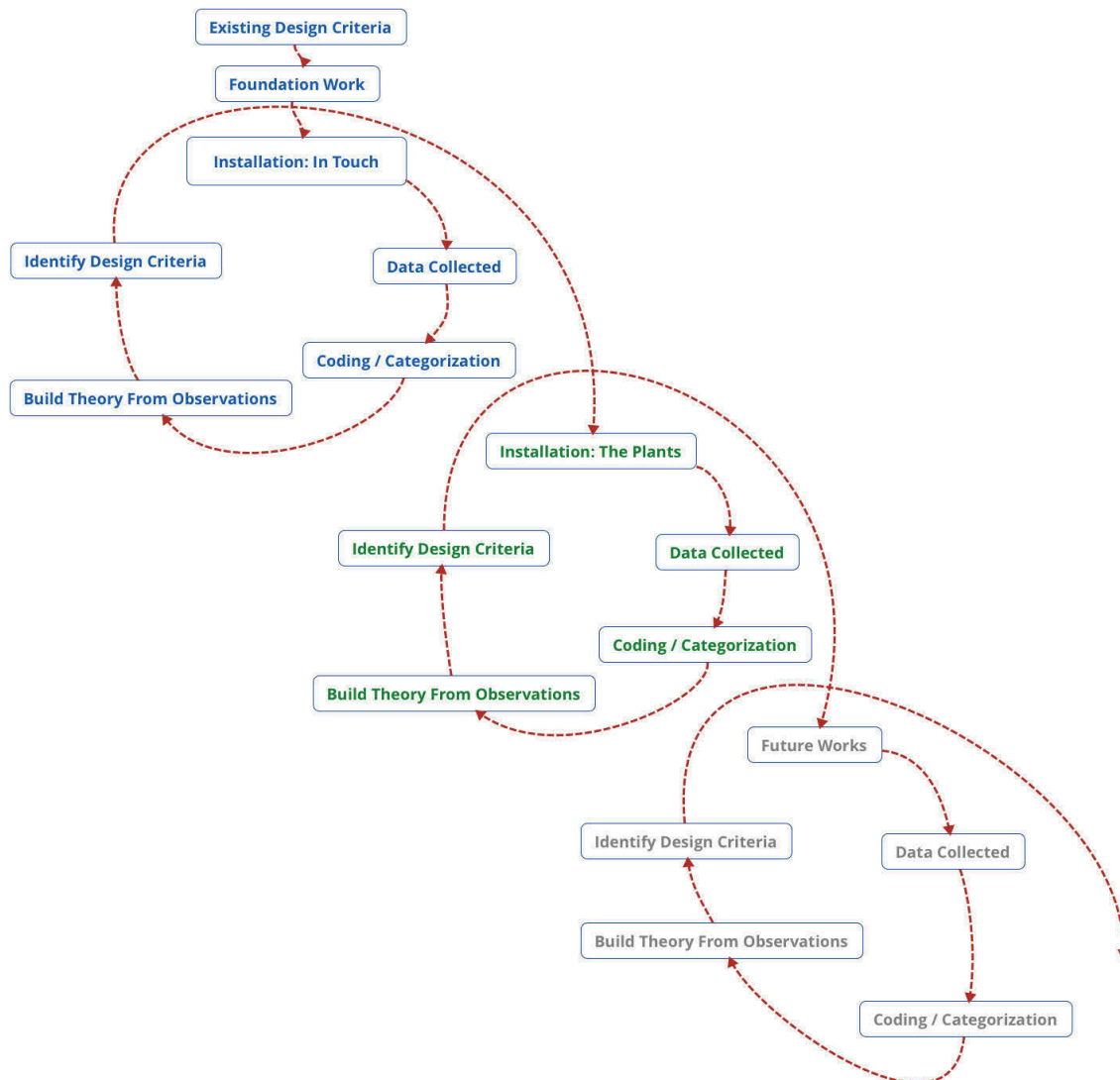


Figure 10 - Research structure influenced by constructionist grounded theory and action research.

4.3 Research Methods

The two questions Crotty considers when creating a research plan are, 'Which methods should be used?' and 'How can these methods be justified?' (1998).

When creating interactive artworks many research methods can be employed and therefore most studies rely on a pluralistic evaluation approach (Jacucci et al. 2009).

Candy & Ferguson suggest that ‘audience experience studies should be regarded as exploratory in nature, often raising even more questions at the same time they provide answers to the ones initially posed.’ (2014, p. 6). With this in mind, I will be utilising a variety of research methods.

4.3.1 Pilot Study Survey Design

Surveys are a somewhat limited approach to data collection but are still used extensively in the evaluation of art experiences. Surveys can be designed in various ways. Jacucci et al. use a simple rating system for evaluating interactive art installations (2009) whereas some use a more formal questionnaire (Yarosh & Markopoulos 2010). The questionnaire or survey can become an important part of the work that simultaneously helps future iterations and enhances the study method (Höök, Sengers & Andersson 2003).

From the literature and research into the artistic development of arts organizations such as *Polyglot Theatre*, I have developed a survey that illuminates the participant experience. However, the limitations of the participant survey are acknowledged:

- It is a subjective form of data collection, as the questions are interpreted by the participant and the answers are in turn interpreted by the researcher.
- The survey relies on participants recalled experience rather than their actual experience.
- They can be affected by age and gender as found in (Jacucci et al. 2009).
- No one likes a survey, often people will take the path of least resistance and tick any box they can to be finished with it.

I will combat these limitations by comparing the findings from these participant surveys with my own observations in the space. I will also create a ‘fun’ questionnaire that will engage (especially a young) participant and challenge them to reflect on their experience in a meaningful way.

The participants of both works were varied in age, this analysis has a focus on the interactions of children. I developed the participant survey used for the pilot study *In*

Touch influenced by research by the 'Child Computer Interaction Group' (ChiCi) ([Read et al. 2006](#)). ChiCi have done many studies that have developed tools for evaluating children's engagement with technology.

4.3.2 Video Analysis

Using a *Go Pro* camera, I filmed 4 hours of footage from *The Plants* installation. The video was analysed and each participant's interaction with the work was timed. Common themes were highlighted with the aim of identifying interaction modes. 'Video documentation provides a means to track participants' movements, duration of engagement, interaction (with the work and with each other) as well as numerous other factors.'[\(Jacucci et al. 2009\)](#). Other popular video documentation methods include video-cued recall in which participants immediately comment on their experiences while watching the footage of their interactions. Video-cued recall has been shown to evoke more specific recollections of activities undertaken ([Omodei & McLennan 1994](#)). This method would be an interesting tool for future study as it would create a more complete picture of a participant's interaction. The problem with video cued recall is that it would require a more controlled setting ([Edmonds, Bilda & Muller 2009](#)).

4.3.3 Collaborator Interview

To develop a greater insight into the creation and impact of these works I interviewed collaborator and composer Cayn Borthwick about his experiences predominately on *The Plants*, he also offered some notes on the *In Touch* installation. He reflected on the process of making these works and his observations of participants' interactions. I will present a transcript of the most pertinent observations. My interview questions were developed based on those used in ([Johnston 2009](#)), ([Johnston 2015](#)) and ([Höök, Sengers & Andersson 2003](#)). The 'interview effect' discussed by Denscombe ([2014](#)) has been considered as the interviewee is someone I have known for a long time. I believe that the insight that Cayn can give especially into the compositional aspects of the works will outweigh any biases due to our relationship as friends.

4.3.4 Field Notes and Recordings

I kept a daily journal throughout the development and presentation of *The Plants*. Each entry was written in the morning about the previous day's experiences as contemporaneous note-taking proved difficult. These notes proved to be important as they helped with recalling specific issues that arose.

I used my *iPhone* to record the music that was created by the participants as the microphone on the *Go Pro* camera was not sufficient for this purpose. These recordings helped me assess the 'sonic environment' that was created. It also allowed me to experience the work as some participants would as audio only.

4.4 Conclusion

In this chapter, I have discussed my research approach, namely constructionist grounded theory. I have also examined the reasons I have decided on the research methods that will be employed:

- A participant survey (for the *In Touch* pilot study only).
- Interview with collaborator, composer Cayn Borthwick.
- 4 hours of video documentation of *The Plants*.
- My own field notes, recordings and memos.

These methods will be used together to create a picture of participants' experiences and behaviours. Each method also offers an insight into the design of interactive touch-based musical installations.

The main questions that I hope to answer are:

- How do people interact with the installations?
- What are the design criteria that will help improve the engagement, interaction and collaboration in future iterations of these works?

As the design criteria will be developed alongside the works that I have created they will influence each other. The design criteria will be used as an evaluation tool for the works created for this thesis and used as a development tool for future works.

In chapter five I will describe the interactive touch-based musical installations that were created as part of this research project. I will also discuss some of the challenges that were part of their creation.

5. Interactive Touch-Based Musical Installations

5.1 Introduction

In this chapter, I will outline the two works that I have produced and studied for this research project. I will discuss my design process and present an overview of the similarities between the works. I will then report on the pilot study of *In Touch* which was developed primarily from independent research and practice undertaken before this research project commenced (see chapter three: Foundation Work). I will discuss observations from a participant survey undertaken for this pilot study. I will show how this development of *In Touch* has contributed to a preliminary set of design criteria that will be used to develop the next work, *The Plants*.

The descriptions herein disseminate the technology, composition, design, and execution of the works. I have tried to cater to researchers who are interested in the mechanics of these works as well as those that are focused on more participatory/interactive engagement elements.

I have found that it can be hard to describe these works in words, their abstract nature is what makes them simultaneously appealing and confounding. For this reason, I have included links to video content³⁷ that feature examples of participants' interaction.

5.2 Design Process

These works were created in collaboration with an engineer, a composer and an illustrator (for *In Touch* only). My role in these collaborations was to design the overall concept of the works and facilitate their creation. For the *In Touch* installation, I worked closely with illustrator Edwina Atkins to design the layout for the gallery. Numerous plans were developed which took into account both the aesthetic and technical requirements of the work. I worked with Michael Henning closely to develop the software and hardware for both *In Touch* and *The Plants*, the process included a

³⁷ See References – Appendix A

lot of trial and error as we experimented with various hardware components (discussed more in 5.4.1 and 5.6.1). I developed the concept for the sound design for *In Touch* and the actual sounds were primarily created by Cayn Borthwick. For the work, *The Plants* Cayn Borthwick had more artistic control over the sound of the work while I focused on the design and fabrication of the installation. Below is a short introduction to my collaborators and a brief outline of their roles.

Michael Henning is a sound engineer, technician, producer, musician, and instrument maker. Henning has provided live sound installation and operation for bands in venues ranging from bars, clubs, and theatres to outdoor festivals and events. He was the in-house sound technician at *Sugar Factory Nacht Theatre*, Amsterdam– 2006-7 and touring sound technician on various national and international tours. As a sound engineer, producer, and musician Henning has worked with some of Melbourne's favourite bands. Henning has created many novel and unique instruments from a sub-woofer double bass to an *Arduino*-powered 'player piano' drum machine. Henning is currently studying Engineering at Melbourne University.

Michael Henning and I started working on software and hardware solutions for interactive touch-based musical installations in 2015. Michael developed the majority of the code for these works, constantly adjusting them as problems arose in situ. He developed code in the *Arduino* IDE and *Python*. I also worked with Michael to develop the hardware components which varied in complexity as described in this chapter.

Cayn Borthwick is a composer whose music is deeply rooted in a sense of place and narrative. Cayn has worked as a performer and multi-instrumentalist with some of Melbourne's most exciting acts including heat-beat aficionado's *No Zu*, trop-pop party starters *Mighty Duke and the Lords* and dream-beat star *Sui Zhen*. He has toured internationally and performed at Australia's premier music festivals including Meredith Music Festival, Falls Festival, Dark MOFO and many more. Borthwick has been the recipient of the Cassidy Bequest Scholarship, the Beleura Sir George Talis Award, and the Global Atelier Overseas Scholarship. He is currently studying his Master of Music at the Victorian College of the Arts and Melbourne Conservatorium

of Music. Over the past four years, Cayn has composed extensively for short film, theatre, advertising, art and contemporary music. Borthwick strives to make music that is both intellectually rigorous and aesthetically pleasing.

As a fellow musician, I have collaborated with Cayn for over three years as part of the tropical party band *Mighty Duke and the Lords*. When I first began developing these interactive touch-based musical installations I realised they would benefit from a strong compositional focus. For *In Touch* Cayn contributed a series of musical phrases, individual notes, a chord framework for the MIDI triggers as well as a sound 'bed' that played on a loop in the space. In *The Plants*, Cayn and I spent a week in the Abbotsford Convent studios developing the sounds for the work from scratch.

Edwina Atkins (illustrator) is a visual artist, illustrator, and potter from Melbourne, Australia. She specialises in observational drawings that quickly convey both pathos and humour. From simple line drawing to complex abstractions, Edwina works between mediums to explore and portray the human condition as seen through her somewhat rose coloured glasses. Her pottery reflects these observations and often incorporates her portraiture into vases, sake jugs and cups. Also, a primary school teacher Edwina has taught across Australia and Japan with a strong focus on integrating the arts into education. Edwina is currently illustrating her first children's book.

Edwina Atkins was involved from an early stage in the development of the *In Touch* installation. Edwina helped develop the concept and using capacitive paint for the first time created a series of paintings that would act as triggers for sounds and music. She was also involved in the overall design and layout of *In Touch*.

5.3 Overview of the Interactive Touch-Based Musical Installations

The design process and collaborators have been introduced, now I will describe the works themselves. The two works: *In Touch* and *The Plants* were created almost eight months apart, in many ways they are separate works utilising different interactive surfaces (conductive paint or plants) and were situated in vastly different

environments (one a gallery, one an outdoor space). There are also undoubtedly some similarities within the works:

- Sounds are triggered using 'capacitive' touch.
- Each work utilised microcontrollers rather than relying on communication with a laptop computer.
- A variety of sounds were experimented with.
- Each work utilised polyphonic sound triggering to create layered sounds.
- Each work was presented to the public.

5.3.1 Using capacitive touch

Capacitive touch sensing technology can be used for many applications, the most common example would have to be the mobile device touch screen. In these works, I am using capacitive touch sensing as a simple 'on-off' trigger. My initial tests with interactive touch-based musical installations (see chapter three: Foundation Work) utilised resistive touch i.e. connecting a 'ground' wire to a sensor through a human body as demonstrated in the popular 'makey makey' kit³⁸. While I am still investigating, the potential resistive touch offers, I felt that capacitive touch was the superior method in the context of these works as it enables free movement without being tethered (to a grounding wire). For both works, we used a variety of boards (described below) that all had some sort of capacitive touch capabilities.

5.4 In Touch (Pilot Study)

*In Touch*³⁹ was commissioned as an 'incubator' season at *ArtSpace*, REALM in Ringwood Victoria and open to the public August 6 – 28 2016. The 'incubator' status of this month-long residency meant that I could be in the space developing and refining the work as the public interacted with it. *In Touch* was developed to be an installation which encourages participants to 'play' the gallery walls like an instrument. As the public enter the *ArtSpace* they see a series of portraits and line paintings on the wall by the illustrator Edwina Atkins. When participants touch

³⁸ <https://www.makeymakey.com/>

³⁹ website for *In Touch*: <http://www.playablestreets.com/in-touch-art-space-1/>

conductive paint on the walls they trigger sounds and musical notes that weave together to create a constantly evolving musical work. Sounds include a series of 12 notes in the pentatonic scale, natural sound effects and other melodic motifs. *In Touch* was developed to create an environment where people of all ages and abilities could 'play' the gallery walls. The public were greeted with this message on the wall inside the *ArtSpace*:

In Touch. Enter a world of sound. Touch the walls to create your own unique music. Conductive paint connects you to a microcomputer which uses capacitive touch (the same technology used in smartphone screens). Take the time to create your own soundscape from the portraits on the wall.

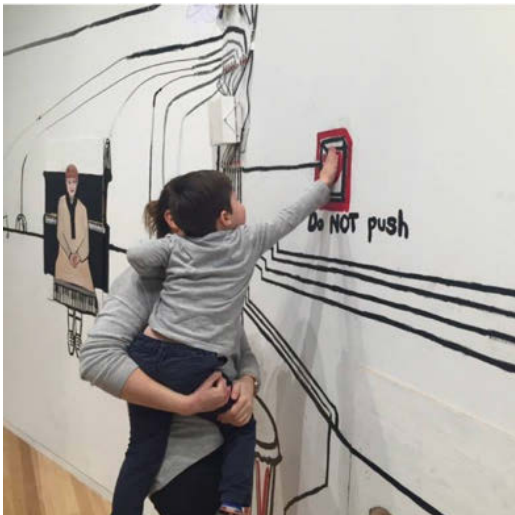


Figure 11 – Discovering sounds together.



Figure 12 – Families playing together

Development Through Workshops

During the month-long residency of *In Touch*, I conducted eight workshops with a diverse range of participants. The workshops began with a warmup and a brief introduction to the technology followed by participants exploring the space and creating sounds. Through these workshops, I developed an insight into how specific groups interact with this work:

- Workshops with pre-school children showed that children as young as two could engage with the work. Some of their interactions seemed like

mimicry and some seemed to be a genuine connection between their actions and the sounds that were being created.

- A workshop was run for the theatre group Your DNA⁴⁰ (consisting of youth who are considered to have physical and intellectual disabilities). This group connected with the work (both literally and figuratively) in different ways. Some were fascinated by the technical aspects (i.e. 'How did touching the paint create a sound?'). Some were intent on finding all the sounds and pointing out the ones that 'didn't work'.
- Several workshops were delivered to primary school students (Grade 1-2). These workshops focused on the creation of compositions and soundscapes mixing sounds that they produced verbally with the ones they could create by touching the gallery walls.
- The workshop for the Chinese Community Social Services Centre's elderly clients with dementia (Aged approx. 50 – 80) showed that an interactive touch-based musical installation can create an environment that can engage older participants in exploration and play.

These workshops contributed to this research project by allowing me to observe specific groups interacting with the work. The main outcome of these workshops was the observation that the *In Touch* installation was accessible to a wide age group and people of differing ability levels.

In the following sections, I will discuss in detail the technology, musical composition and design of *In Touch*.

5.4.1 Technology

The proliferation of maker technologies has meant that children are interacting with technology in new and novel ways from wearable controllers (Trappe 2012) to ad hoc musical instruments (Jensenius, Koehly & Wanderley 2005). For the *In Touch* exhibition, Michael Henning and I built upon our existing experiments with *Arduino*-based microcontrollers that we had started with the *Playable Streets Test Sites* work

⁴⁰ Website for Your DNA: <http://www.yourdna.com.au>

(see chapter three: Foundation Work). These devices were all built on an *Arduino Uno* or *Mega*, and were topped by a prototype ‘hat’ or ‘shield’ that consisted of a series of 1.5M ohm resistors to facilitate capacitive touch capabilities. Two units retrieved audio from the *Robertsonics WAV Trigger Board*⁴¹ which I had chosen specifically for its polyphonic capabilities. It was surprisingly hard to find polyphonic solutions at this time which led to frustrations in other parts of the work such as the actual sounds that we could use (discussed further below). Another *Arduino* was paired with the *Adafruit "Music Maker" MP3 Shield for Arduino*⁴². The MP3 encoder would not allow polyphony so we enabled the on-board MIDI mode (which can be played polyphonically) by soldering two connections on the board and reprogramming it through the *Arduino IDE*. The Capacitive Sense Library by Paul Badger⁴³ was the foundation of the code used on the *Arduino*-based system.

In addition to the three *Arduino* units, we used two *Touch Boards* created by *Bare Conductive*⁴⁴ (who also make the conductive paint used in the work). The *Touch Board* is designed specifically to work with conductive materials, based on an *Arduino Leonardo* with a capacitive touch chip and an onboard MP3 player. The *Touch Boards* were essentially ‘set and forget’ needing very little work to set up.

⁴¹ <https://robertsonics.com/wav-trigger/>

⁴² <https://www.adafruit.com/product/1788>

⁴³ <http://playground.arduino.cc/Main/CapacitiveSensor?from=Main.CapSense>

⁴⁴ <https://www.bareconductive.com>

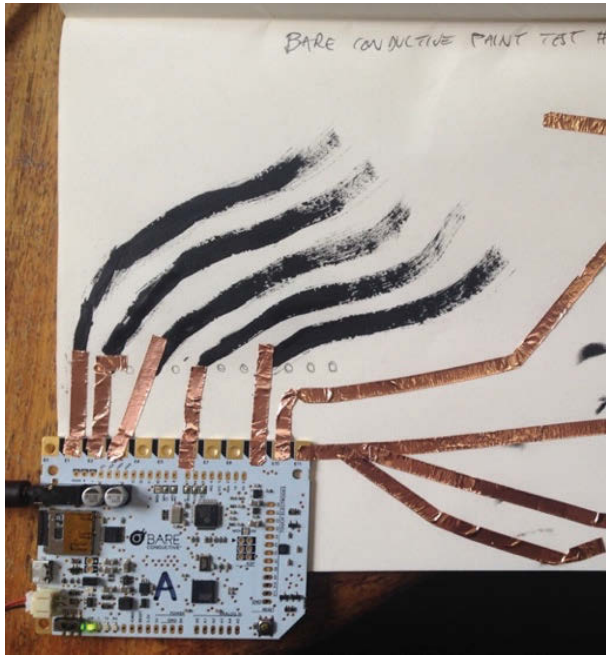


Figure 13 - Initial tests (using copper tape and conductive paint) of the 'Touch Board' (with 8GB micro SD card loaded with samples) created by Bare Conductive, London.

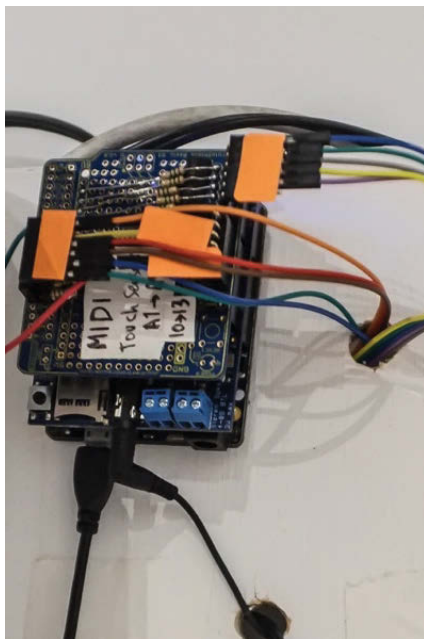


Figure 14 - 'MIDI 8': An Arduino uno, Adafruit "Music Maker" MP3 Shield for Arduino

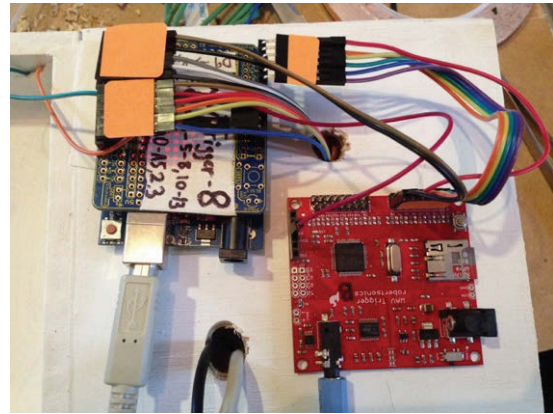


Figure 15 - 'WAV Trigger 8': An Arduino Uno, robertsonics WAV Trigger board (with 8GB micro SD card loaded with samples) and an Arduino prototype shield with 8 1.5M ohm resistors.

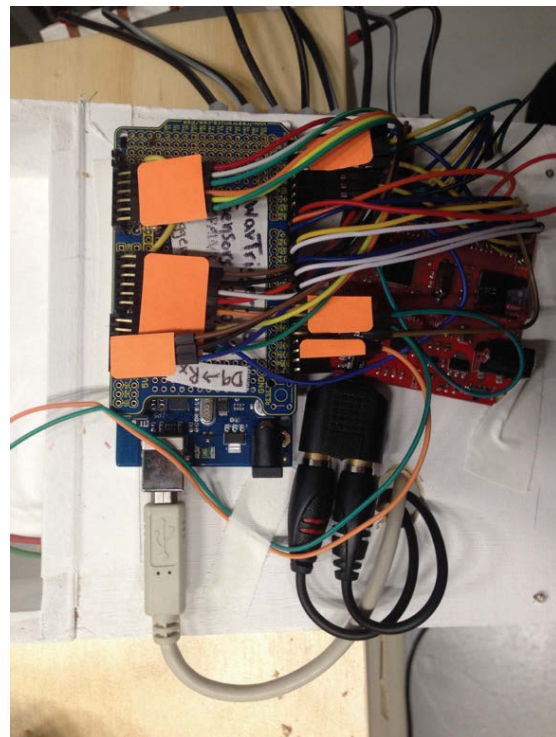


Figure 16 - 'WAV Trigger 16': An Arduino MEGA, robertsonics WAV Trigger board (with 8GB micro SD card loaded with samples) and an Arduino prototype shield with 8 1.5M ohm resistors



Figure 17 - Michael Henning coding on the fly in the ArtSpace gallery.

5.4.2 Sound

Cayn Borthwick developed a series of melodic phrases and sound effects based around the C major pentatonic scale. He also selected notes that the MIDI instrument mentioned above would play within this scale. A 'sound bed' played continuously which featured natural sounds such as birds and an evolving musical soundscape in C Major that changed slowly over 37 minutes (and then looped).

As this work was installed in a public gallery attached to a library sound level considerations had to be made and the soundtrack had to be at a volume that would be both satisfying for the participant and not too obstructive for library visitors and staff. Speaker placement was key. We placed six speakers in the lighting rig above the participants.

5.4.3 Design

The main concept of *In Touch* was to create an 'interactive exhibition', turning the gallery into a place where people were encouraged to touch the art rather than appreciate it from a safe distance as in most galleries. We were inspired by other galleries that have been creating interactive installations, inviting the audience to touch artworks such as the *Multisensory Met Project*⁴⁵ and the Louvre's *Tactile Gallery*⁴⁶. Edwina Atkins began working on the original portraits of local residents a month before the installation of *In Touch*. Edwina created portraits of people that she had observed around the Ringwood area on a couple of scouting missions. The portraits were painted with acrylic paint on MDF boards, conductive paint was then applied to certain sections of the paintings. We installed the paintings onto the walls of *ArtSpace* over 2 days and wired them to the microcontrollers. An unintended consequence of using the slightly porous conductive paint was that participants left finger marks on the gallery wall, especially where the most 'popular' sounds were. This created a trail of participant interaction which was an interesting way to track engagement.



Figure 18 - Measuring interaction with fingerprints.

⁴⁵ <https://www.metmuseum.org/blogs/digital-underground/2015/multisensory-met>

⁴⁶ http://tucson.com/entertainment/please-touch-louvre-opens-room-for-blind-and-visually-impaired/article_d3c73526-023a-5107-bed9-1b58abfa9352.html



Figure 19 - A view of one of the walls in the In Touch work.



Figure 20 - A view of one of the walls in the In Touch work.



Figure 21 - A participant interacting with the installation.



Figure 22 - A view of the *In Touch* installation.

5.4.4 Participant Survey

A participant survey (and corresponding consent form) was completed by sixteen participants in the final ‘family day’ of the *In Touch* exhibition. As I had not yet defined the design criteria for the work some of the questions may seem off topic. I believe they were useful to obtain a clearer picture of the participant’s experiences of the work.

The questions were as follows:

- Name
- Age
- Would you say you are:
 - o Curious
 - o Shy
 - o Brave
 - o Silly
 - o Noisy
 - o Quiet

(Feel free to tick more than one)
- Tell me about your experience with In Touch.
- Do you like the music or sound effects?
- Did you feel like you were making the sounds happen?
- Did you play with others or on your own?
- What sounds would you like to hear?
- Do you play an instrument? If so what instrument?
- What were the best things about In Touch
- What were the worst?
- How did you hear about this exhibition?

IN TOUCH

IN TOUCH Participant Survey:

Name: Ella Age: 7

Would you say you are:

| | |
|---------|-------------------------------------|
| Curious | <input checked="" type="checkbox"/> |
| Shy | <input type="checkbox"/> |
| Brave | <input checked="" type="checkbox"/> |
| Silly | <input checked="" type="checkbox"/> |
| Noisy | <input type="checkbox"/> |
| Quiet | <input type="checkbox"/> |

(Feel free to tick more than one)

Tell me about your experience with IN TOUCH?

Finding out the music
Exploring

Did you like the music or sound effects?

Yes

Did you feel like you were making the sounds happen?

No

Did you play with others or on your own?

Others

What sounds would you like to hear?

Not sure

Do you play an instrument? If so what instrument?

Keyboard
Recorder

What were the best things about IN TOUCH?

The Noises.

What were the worst?

I don't know

How did you hear about it this exhibition?

Family .

Figure 23 - An Example of the In Touch participant questionnaire.

5.4.5 Results and Discussion

This pilot study taught me a lot about interactive touch-based musical installations both in practice and research. Over the month, the installation was attended by approximately 600 people. The 8 workshops were delivered to approximately 40 participants at a time. In order to examine participant's experiences with the installation, a short survey was conducted on the final day of the work. Sixteen participants, aged between 6 and 62, filled in the surveys, providing some initial feedback and allowing me to draw some preliminary conclusions:

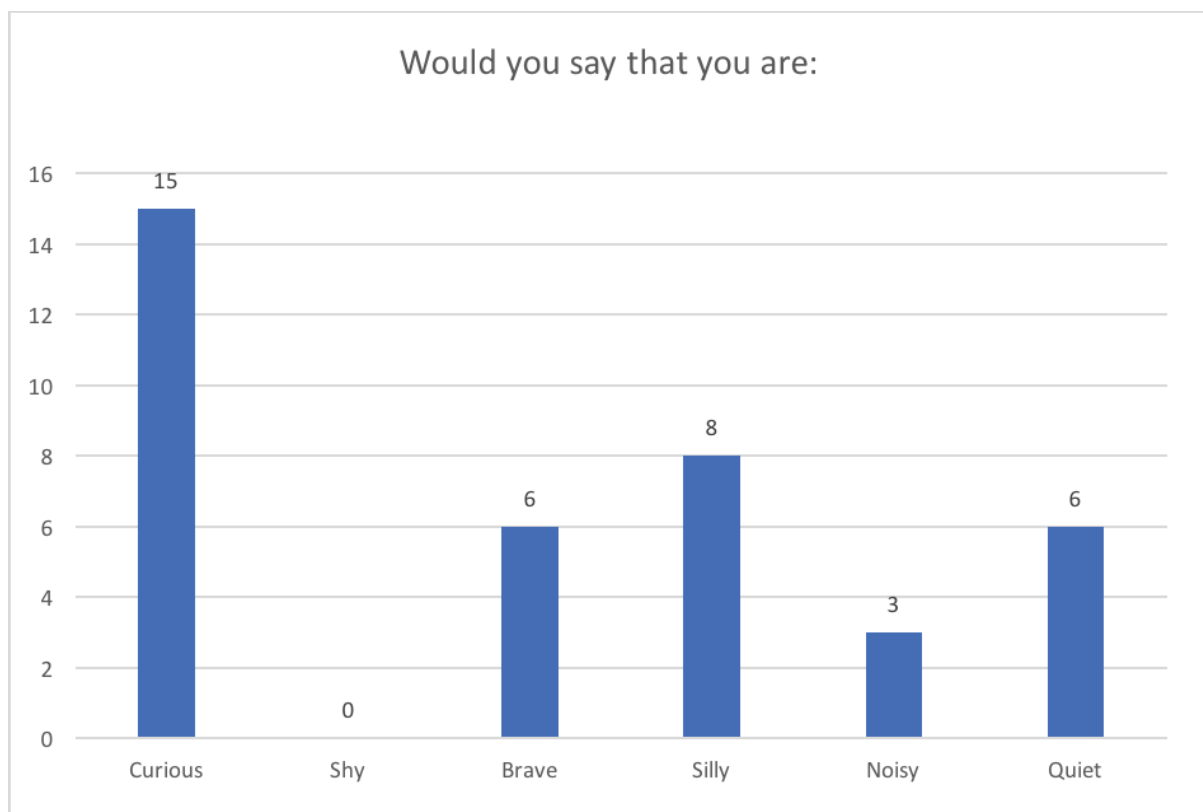


Figure 24 - Question 1: Would you say you are...

The first question I asked was designed to get an understanding of the temperament of the person experiencing the installation. It was a good start to find that the majority of participants felt 'curious' from the beginning. This sense of curiosity was observed throughout the one month-installation.

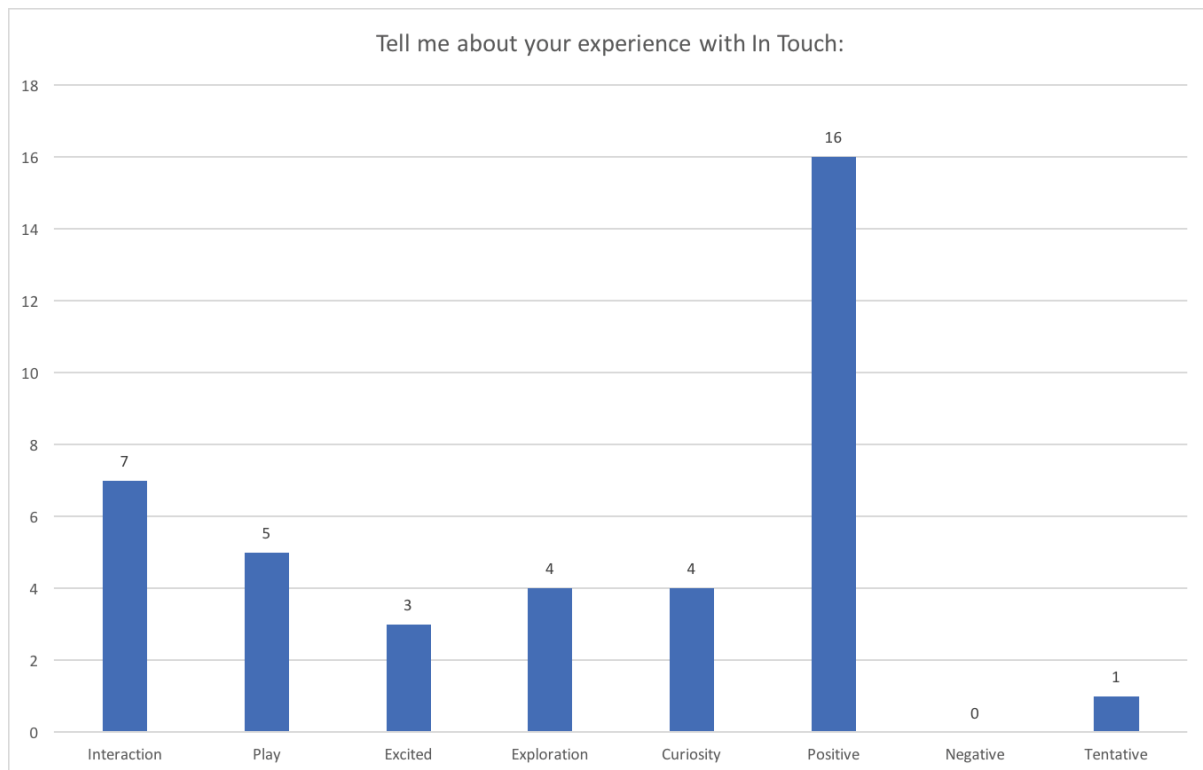


Figure 25 – Question 2: Tell me about your experience with In Touch.

| Code | Definition |
|-------------|---|
| Interaction | Mentions interaction directly or discusses play with others. |
| Play | The answer suggests that games were developed or specifically refers to playing in the space. |
| Excited | The answer shows anticipation and a general excitement about the installation. |
| Exploration | Discusses exploring or experimenting in the space. |
| Curiosity | The answer questions how the technology worked or discusses wanting to find out more. |
| Positive | Phrases like 'loved it' or 'we had so much fun' would indicate a positive reaction. |
| Negative | Any phrase that indicate a negative response such as 'boring', 'upsetting' or 'too loud' |
| Tentative | Mentions being tentative or reluctant to engage at first. |

Figure 26 – Coding table for Question Two.

The open-ended responses to question two were coded using grounded theory technique. Example of this coding process: “Brought our 14-month-old baby. Great fun for him to interact.” This would be coded with ‘Interaction’ and ‘Positive’. “We loved experimenting with the sounds in the room and the interactions with the paintings.” would be coded as ‘Interaction’, ‘Play’, ‘Exploration’, ‘Curiosity’, ‘Positive’. Whilst all participants of the survey said that they had a positive experience with the installation they described many different reasons for this positive experience.

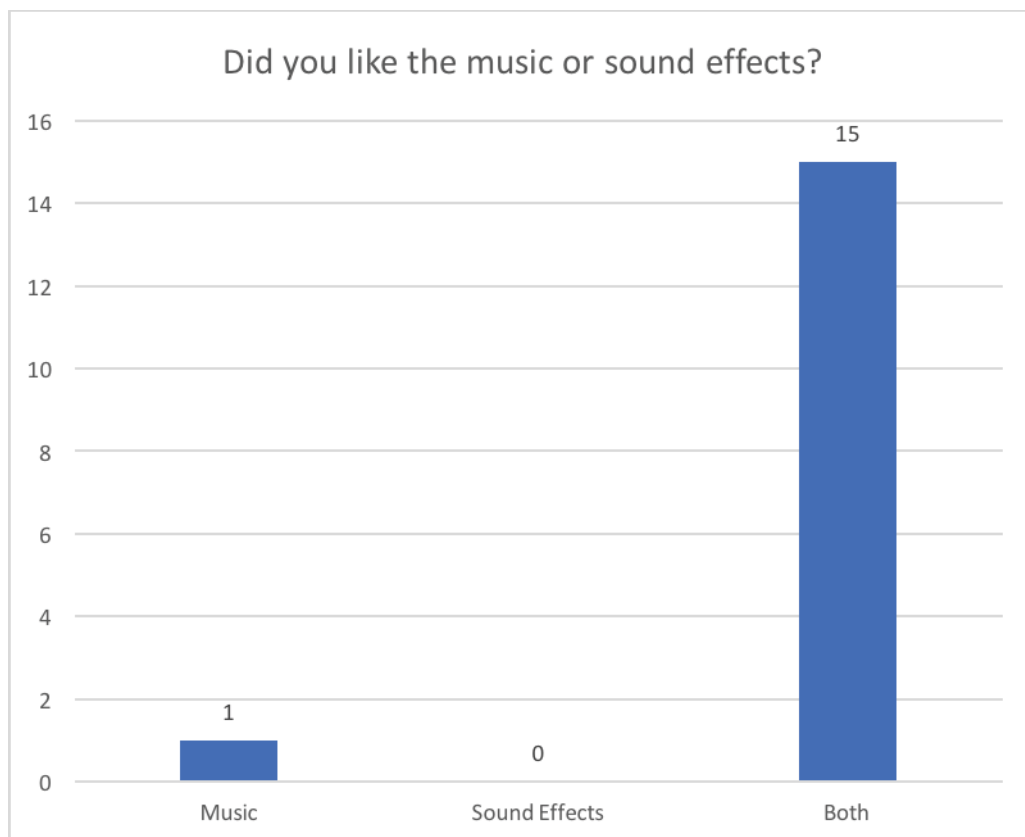


Figure 27 – Question 3: Did you like the music or sound effects?

The majority of those surveyed liked both the music and the sound effects of *In Touch*.

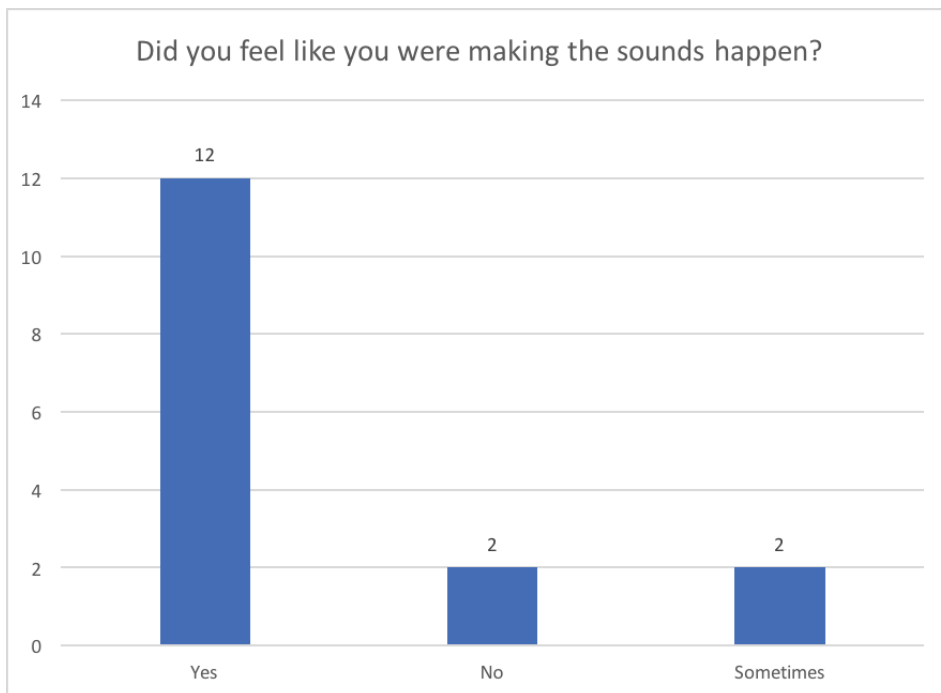


Figure 28 – Question 4: Did you feel like you were making the sounds happen?

Whilst most people did feel that they were in control of the sounds 1/3 of respondents said they only felt in control sometimes or not at all.

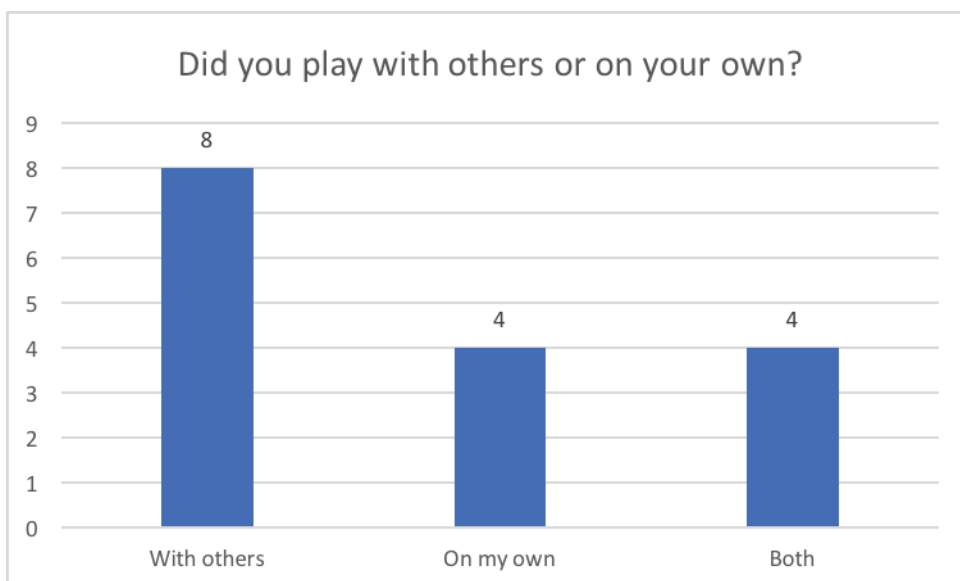


Figure 29 – Question 5: Did you play with others or on your own?

Half of the respondents played with others in the gallery. I observed this trend over the duration of the installation. Within the workshop context, there was much more collaborative play.

Question six: ‘What sounds would you like to hear?’ was intended to be a design tool for future works. Sound effects and percussive sounds seem to be the most popular with these respondents. This may be a result of those particular sounds being the most reliable within the *In Touch* exhibition.

Question seven: ‘Do you play an instrument? If so what instrument?’ was intended to get a general idea of the instruments that people play. This will inform the choice of sounds used in future works. Perhaps unsurprisingly piano/ keyboard and guitar were the most popular instruments.

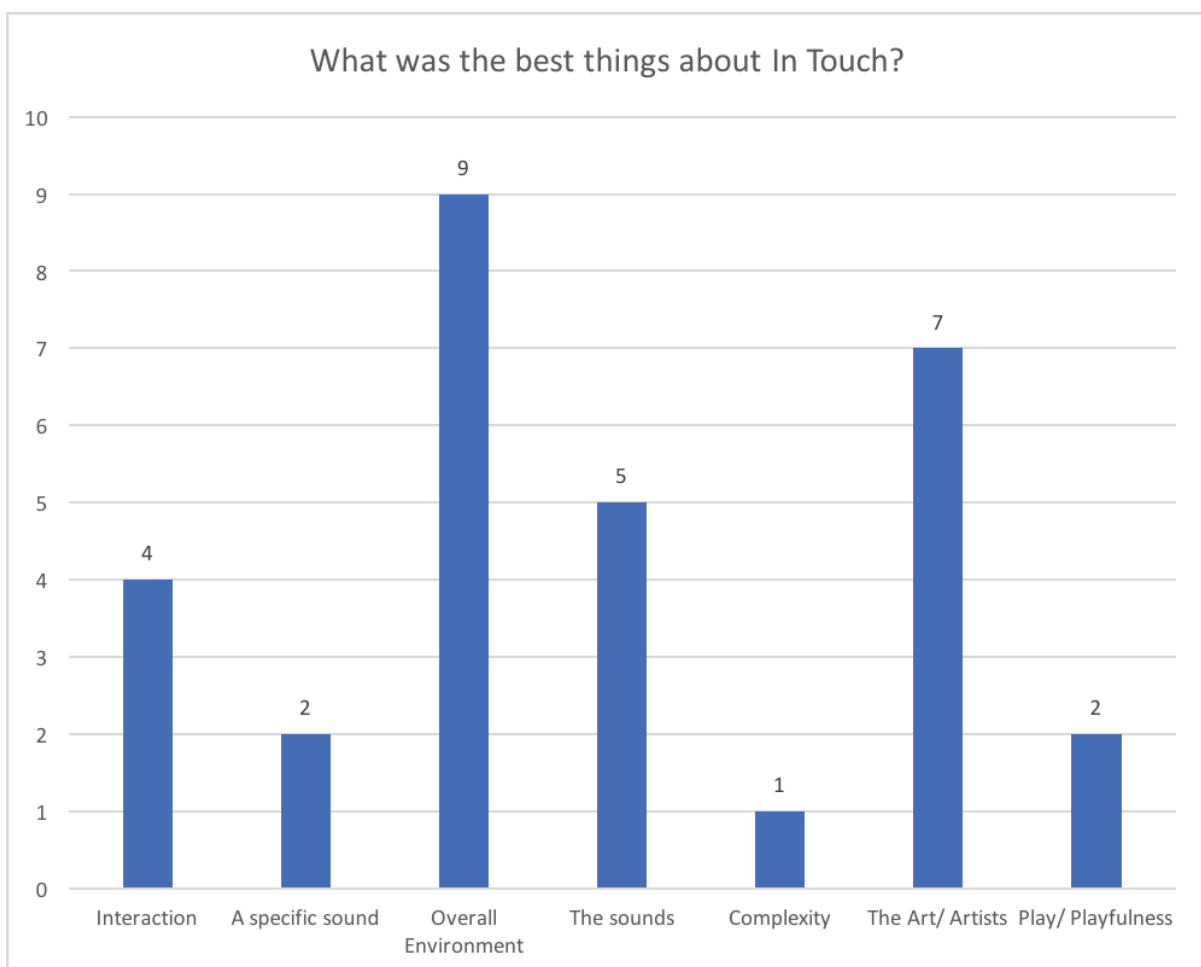


Figure 30 – Question Eight: What was the best things about In Touch?

| Code | Definition |
|---------------------|---|
| Interaction | Mentions interaction directly or discusses play with others. |
| A specific sound | The response discussed a single sound such as an instrument or a sound effect. |
| Overall Environment | A general response that suggest that the participant enjoyed the whole experience. |
| The Sounds | A more general response to the sound in the space (as opposed to 'a specific sound'). |
| Complexity | Complexity of the installation is mentioned. |
| The Art/ Artist | The visual aspect of the installation or the artists are specifically discussed. |
| Play/ Playfulness | The answer suggests that games were developed or specifically refers to playing in the space. |

Figure 31 – Coding table for Question Eight.

The open-ended responses to this question were coded using grounded theory technique. Example of this coding process: If a participant said they used the “Do Not Push Button” (a painted button that made a loud siren sound when touched) this would be coded as ‘A specific sound’. “Lovely idea of having actual people drawn like interacting with real people and sounds.” would be coded as ‘Interaction’, ‘Overall Environment’, ‘The Art/ Artist’.

People found that the overall environment was the best part of the work. Almost a third of respondents liked the sounds specifically.

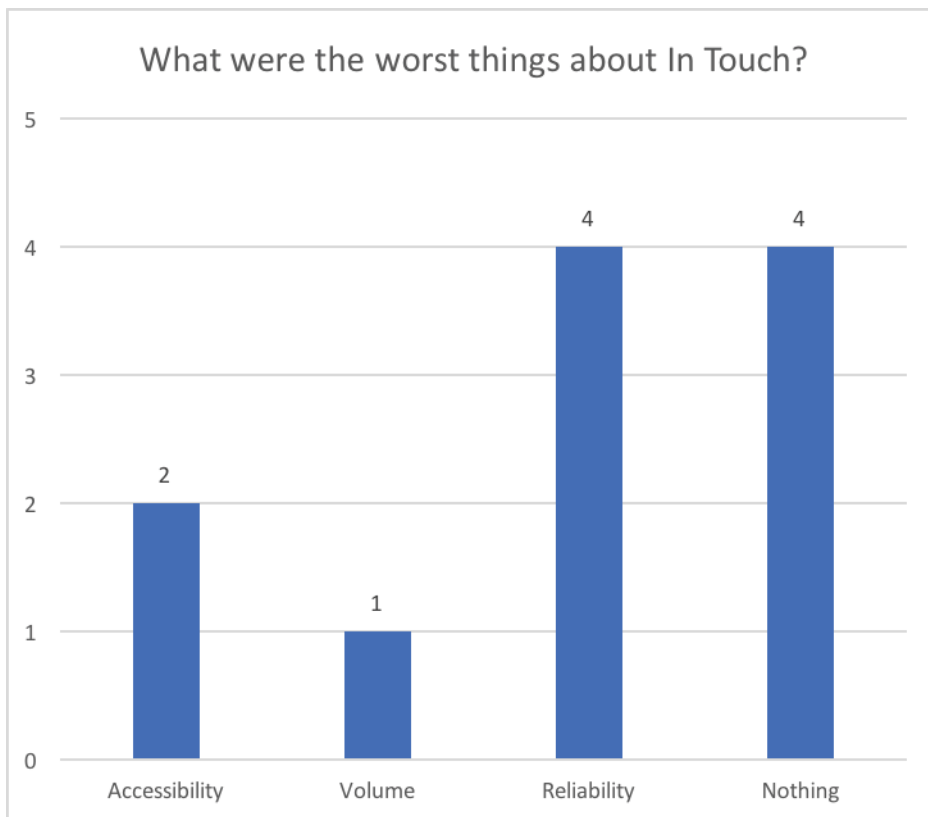


Figure 32 – Question 9: What were the worst things about In Touch?

| Code | Definition |
|---------------|--|
| Accessibility | Issues around accessibility are raised (such as not being able to reach some of the contact points). |
| Volume | A problem around the volume of the installation. |
| Reliability | Mentions that the installation has parts that are sometime 'not working'. |
| Nothing | Nothing was highlighted as a problem with the installation. |

Figure 33 – Coding table for Question Nine.

The open-ended responses from this question were coded using grounded theory technique. Example of this coding process: "Some things don't make sound." This would be coded with 'reliability'. "Volume could be overwhelming when many people in space." would be coded as 'volume'. The reliability of the work is a problem for ¼ of the participants. I observed that some participants found that the sounds wouldn't

trigger immediately after they touched the paint. Some areas that looked like they should work (i.e. copper tape ran to that point) would not always trigger a sound.

General observations:

- Generally, people found the exhibition engaging and interesting.
- Suggested sounds for future iterations of the work included voices, percussion, acoustic instruments and animal sounds.
- I observed people engaging with the work and often taking special care to trigger all the sounds. I also witnessed participants finding one sound and triggering it repeatedly.
- The sound source was not always near the sound activation point. This was one of the main problems with the work and will be a strong consideration in the next work.
- Bright and joyful sounds were perceived as 'more satisfying' these sounds were generally musical motifs and riffs in a major key. Some of the harsher sound effects such as a sprinkler sound or jangling keys were not triggered much at all.
- It would have been beneficial to collect more data. 16 surveys is not a large sample size and limits the confidence we can have that the findings are generalizable.
- Extended video documentation would have been helpful as it would have given me an insight into the behaviours of a larger number of participants.
- An important practical consideration is to allow time for three main things, input (from participants), reflection of said input and time to implement changes 'on the go', constantly updating and transforming the work.
- The slightly porous conductive paint meant that fingerprints started to form around the paintings, leaving a natural trail of the participants' journey.
- These trails helped future visitors identify popular areas of interaction and illustrated the areas on the wall that would trigger sound.
- The *In Touch* exhibition allowed us to experiment with the connection between imagery and sound. We played with perception and expectation by connecting imagery that was not related to the sounds they activated. For example, touching the image of a flower would set off a melodic trill, touching

the outline of a cat would trigger the sound of a bird etc. We found that this could be a good source of comedy and interest.

5.5 Preliminary Design Criteria

In Touch led to many discoveries about the design of interactive touch-based musical installations. In this section, I will discuss the observations and suggest preliminary design criteria that will inform the creation of the next work *The Plants*. This design criteria will be further developed at the end of this thesis.

Observations:

- The height of paintings was an issue which made some areas of the work inaccessible for small children, although it did encourage parents to pick up their children and help them interact with certain areas of the work which is a positive outcome.
- The installation space was open all day which meant that many people could simply walk into the gallery and begin touching the walls with little instruction.
- The invitation into the space is important: when participants saw people in the space playing they were much more likely to join in.
- There seemed to be more solo exploration rather than interaction between people.
- Workshops were a great way to engage the community.

Proposed design criteria: The installation should be accessible, encourage exploration and interaction. (Accessibility)

The main goal of these interactive touch-based musical installations is to engage the public in explorative music making. It is important that the work is inviting, engaging and accessible for all. The environment and installation should encourage people to interact with the work and each other.

Observations:

- Participants mostly felt that they were affecting the sounds in the space. 1/3 said they only felt in control sometimes or not at all.
- More localized sound sources (i.e. speakers closer to triggers) could potentially heighten this effect.
- I found that shorter, uncomplicated notes, percussive hits or sound effects were the most effective sounds as they encouraged 'building' compositions.

Proposed design criteria: The user should feel like she/ he is responsible for creating the sound in the space with their touch. (Control & Agency)

The first moment of interaction is so important, the participant needs to feel that their choices and actions have true consequence. This criterion should permeate all of the steps in the design process from coding, to hardware to design, composition and speaker placement.

Observations:

- Some frustration was caused (by the participant and the artist) when some areas were inconsistent.
- More work should be done in the design phase to test the consistency of the work, making sure to test the work in the environment that it will be installed if possible.
- Within this work, we experimented with various microcontrollers (*Arduino*, *Wav Trigger*, *MP3 Board* and the *Bare Conductive Board*) and found that they all had their own advantages and disadvantages. We initially expected to find a superior system to facilitate interaction, instead, we found that each system encourages people to interact in different ways.

Proposed design criteria: The interface should be consistently responsive. (Consistency)

"It's not woouooooorking" (child aged 6), this is a response that probably rates as number one participants' (and designers') frustration. The interactive work should be as responsive as possible.

Observations:

- The participant survey feedback and observations point towards the installation being fun.
- Play and interaction were the most prominent themes of people's experience with *In Touch*
- There were plenty of smiles amongst the participants.
- This was especially evident in the workshops.
- Further explorations should consider performative elements, or games based around the installation.

Proposed design criteria: The installation should be fun. (Fun)

What's the point if it's not fun? I hope to invoke a musical curiosity and expose people to the joy of making music but ultimately, I want these works to be fun. The ability to interact and create games would add to this sense of fun.

These design criteria will be reassessed and amended in chapter seven according to observations in chapter six.

5.6 The Plants

The Plants is a site-specific interactive touch-based musical installation that invites participants to create their own compositions using a variety of plants as the instrument. This installation was presented on a busy through way at the Abbotsford Convent over two days (10 am – 4 pm Saturday the 20th and Sunday the 21st of May 2017). The installation consisted of 12 plants on a custom-made wooden stand that housed the plants as well as the *Raspberry Pi*, effects unit, mixer, and speakers. Cayn Borthwick and myself were present throughout the installation, we facilitated engagement or simply observed participants and answered questions about the work.

Beside the installation of *The Plants* we had a small stand-alone experiment that consisted of two plants on a table with a guitar amplifier below. This was an

experiment that arose during the development of *The Plants*, two plants sensed the proximity of participants' hands acting as a Theremin-like device. This part of the installation (referred to as 'Plant Theremin') served as an area where people could play when the main installation got too crowded.

Hundreds of people interacted with the work and created music over the two-day installation. A wide variety of ages were observed interacting with the work. *The Plants* was commissioned by the Abbotsford Convent Foundation as part of the *Alchemy Arts* program. Please note that *The Plants* was originally titled *PLAY Space* and this is what it is called on the Abbotsford Convent website.⁴⁷



Figure 34 - *The Plants* installation at the Abbotsford Convent.

5.6.1 Technology

The Plants was built around a *Raspberry Pi A+* and the *Pi Cap* capacitive touch hat by *Bare Conductive*. Sounds were created in the *DAW Logic* and loaded on the board via *FileZilla* software over SFTP (Secure File Transfer Protocol). Two momentary push buttons were connected to the *Pi Cap* one reset the board, one controlled the sound bank selection (sound banks included a piano, a synthesizer and bird sound effects).

⁴⁷ <https://abbotsfordconvent.com.au/whats-on/events-exhibitions/playspace>

The software used for this installation was developed initially for the Clippy V1.0 project as described in the future work in chapter eight. The code was programmed in *Python* by Michael Henning.

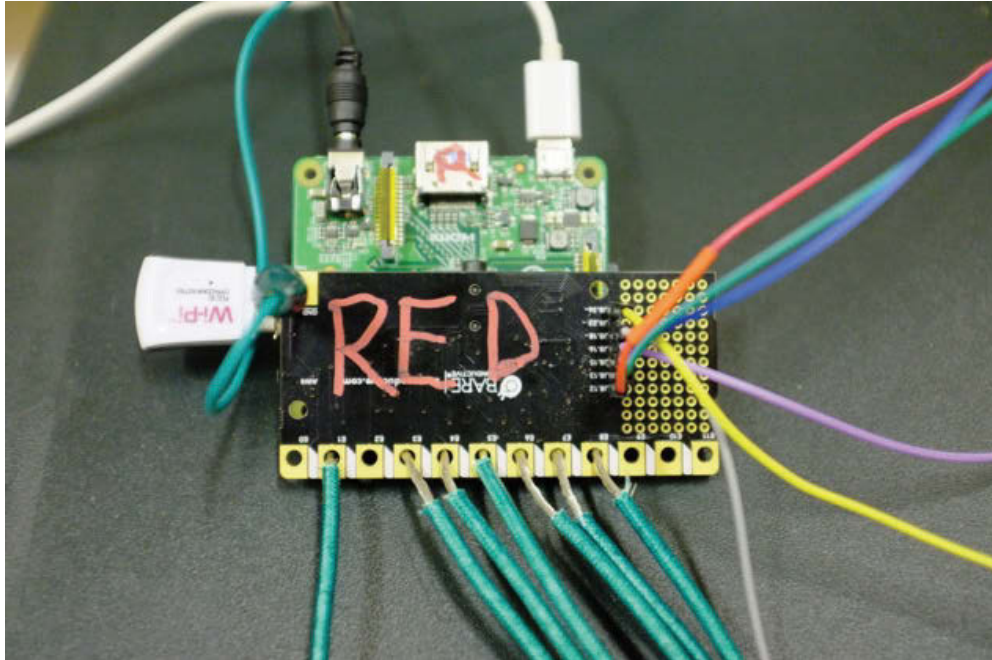


Figure 35 - The Bare Conductive Pi Cap on the Raspberry Pi A+ connected to a USB power supply, WiPi USB Wi-Fi dongle and 3.5mm audio jack.



Figure 36 - The plants were connected by insulated wire connected to a metal 'L' bracket.

5.6.2 Sound

Three banks of sounds were developed for *The Plants* installation. The first was a clean piano sound. The twelve plants triggered a collection of notes based on the harmonic series. Specifically, the notes were C1, C2, G2, C3, E3, G3, Bb3, C4, D4, E4, F#4, G4. Structures present in the Harmonic series, the pillar of tonal music, are used regularly in film scores. For example, John Williams utilises the perfect 5th, the first and second overtones to depict heroism in *Superman*, *Star Wars* and *Harry Potter* films ([Audissino 2017](#)).

The second bank was a series of bird sounds, trills, squawks, and warbles. These were short (approximately 2 seconds) samples. The third bank of sounds consisted of a synthesizer that had a sharp attack and a modulating tail using the same notes as the piano.

With this installation, we had the opportunity to have the sound source close to the points of contact (i.e. the plants). The speakers were embedded under the plants in the wooden frame that cradled the plants. We also didn't have the same volume restrictions as we did for *In Touch* as the installation was situated in an outdoor area. The combination of location and volume meant that there was immediate audio feedback from a participant's touch.

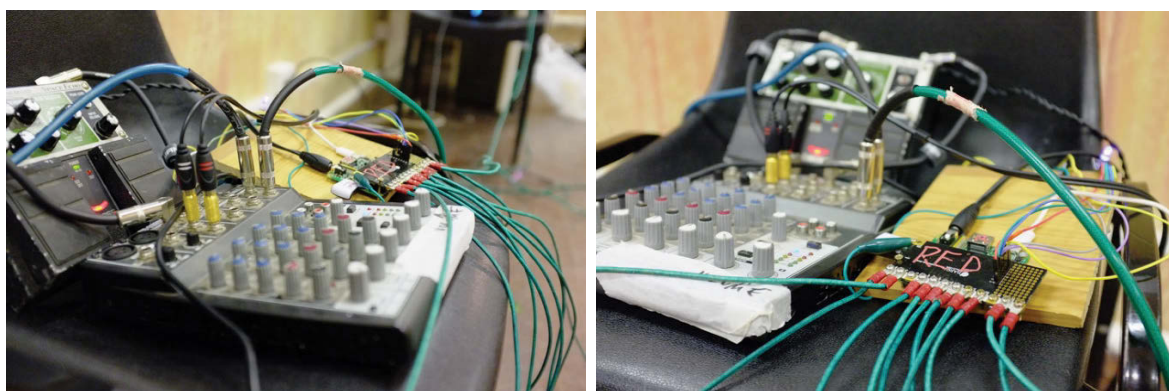


Figure 37 & Figure 38 - The Raspberry Pi is connected via 3.5 mini jack to a Behringer Xenyx 802 mixer. The Boss RE20 Space Echo was used to add reverb.



Figure 39 & Figure 40 - The output of the mixer is connected to 2 Yamaha HS5 monitor speakers (shown here with a plastic lid to protect the speakers from water dripping from the plants).

5.6.3 Design

This installation was vastly different to the design of *In Touch*. The installation needed to be set up and packed down relatively quickly so this had to be factored into the design. The structure was divided into three sections, the middle section housed the *Raspberry Pi*, mixer and effects unit, the other two sections contained the speakers. Each section contained 4 potted plants that fit in circular holes in the top of the structure. An insulated wire connected to an 'L' bracket was stuck in the soil of each plant which connected the plant to the *Pi Cap* capacitive touch sensor.

We used a variety of plants sourced from local nurseries, including succulents, flowers, and ferns. As these plants acted as sensors for the *Pi Cap* capacitive touch unit they all reacted slightly differently when touched. Some would activate a sound from the slightest touch and some would need a whole hand to cover the plant to trigger the sound.

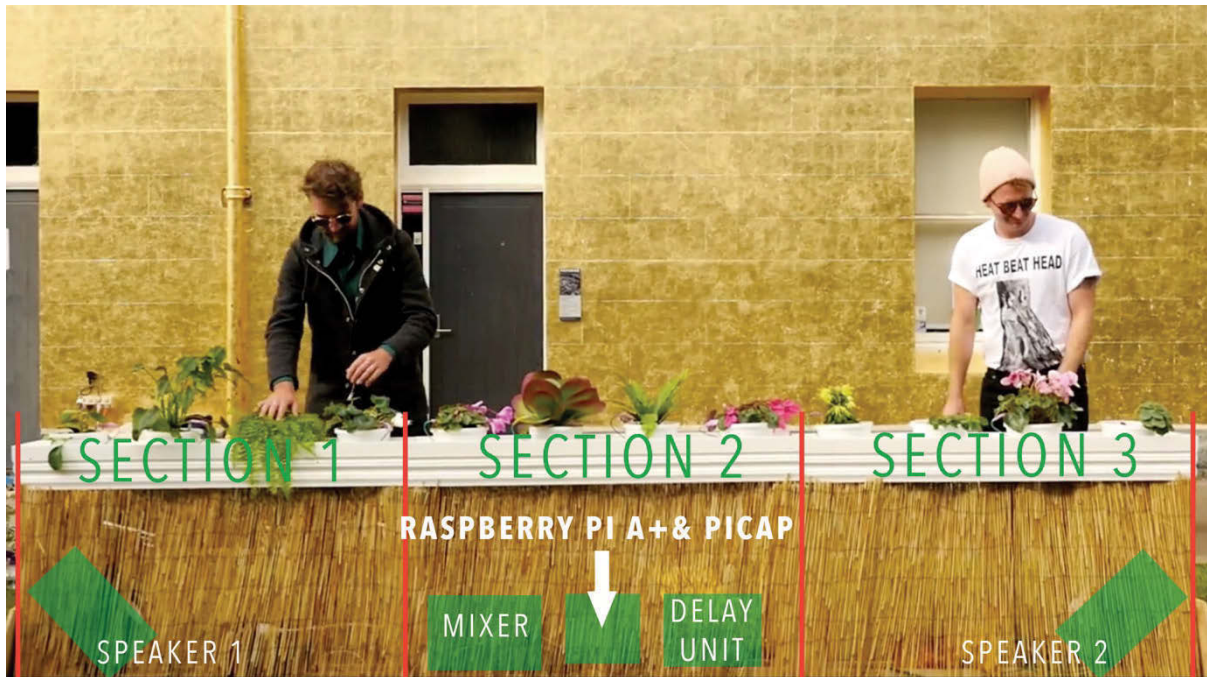


Figure 41 - *The Plants* design.

5.6.4 Connection to Preliminary Design Criteria

The creation of *In Touch* led to a set of preliminary design criteria. Below are some notes of how *The Plants* was created in relation to this preliminary design criteria.

- **The installation should be accessible, encourage exploration and interaction. (Accessibility)**
 - We created *The Plants* installation structure so that it could be accessed by children and adults. We believed that 80cm would be a good height to cater to a broad age range. We also wanted to encourage the phenomenon that we witnessed in the *In Touch* exhibition of parents lifting their small children to interact with the work.
1. **The user should feel like he/ she is responsible for creating the sound in the space with their touch. (Control & Agency)**
 - We considered this design criterion when placing the speakers directly below the point of contact and setting the volume for the work. It was important for the participant to hear the sounds activating clearly and immediately. This outdoor setting allowed us to use a louder volume setting.

2. The interface should be consistently responsive. (Consistency)

- This was an important aspect of creating *The Plants* installation, we spent a lot of time making sure that the points of contact were very responsive. We selected plants that were the most responsive (i.e. generally those with a higher water content such as succulents).
- This is the main reason we decided to use *the Raspberry Pi* and *Pi Cap* rather than the *Arduino* systems that had many problems during *In Touch*.

3. The installation should be fun. (Fun)

- We designed the structure for the installation to be light and inviting, it had to look functional (i.e. like a flower bed) but at the same look different enough to invoke curiosity in people who pass by.
- We felt that the abstract nature of playing plants and hearing a piano, birds or a synthesizer would be quite fun for participants.

5.7 Conclusion

In this chapter, I have outlined the design process and given an overview of the interactive touch-based musical installations created for this research project.

I then described in detail the creation of *In Touch* including installation, development through workshops, technology, sound, and design. I then presented the findings from the participant survey and outlined key findings.

These findings influenced preliminary design criteria which were used to develop the primary study *The Plants*. I have described the technology, sound and design of the interactive touch-based musical installation *The Plants*. Finally, I have shown how the preliminary design criteria influenced this work.

In the next chapter, I will look at the data collected from *The Plants* installation and discuss the findings from this data.

6. Observations

6.1 Introduction

In chapter four I outlined the methodology of this research project. In chapter five I described the works that were created and discussed their operation. I also outlined the findings from the *In Touch* installation and presented a preliminary set of design criteria. In this chapter, I will outline the observations of *The Plants* installation at the Abbotsford Convent using a variety of research methods. Video documentation, an interview with composer Cayn Borthwick, my journal entries and recordings will be presented. Finally, I will discuss these findings, highlighting common themes and behaviours.

6.2 Method Summary

In this chapter, I will present data from a variety of sources including:

- 4 hours of video documentation of *The Plants* installation at Abbotsford Convent. The video footage has been examined and notes from this examination have been coded to find common themes and modes of interaction.
- An interview with collaborator and composer Cayn Borthwick. I asked him about the process of creating *The Plants* and ways that the work could be improved. We also discussed modes of interaction within the work.
- Journal entries and audio recordings that were deemed relevant to this research.

By analysing these sources and identifying potential correlations I hope to answer the following questions:

- How do people interact with the installations?
- What are the design criteria that will help improve the engagement, interaction and collaboration in future iterations of these works?

6.2.1 Primary Source: Video Documentation

The Plants installation was open to the public for a total of 13 hours over the two days. Four hours of video was taken of *The Plants* at the Abbotsford Convent on May 20 & 21 (Approximately 2 hours on each day). All four hours were analysed in depth. Participants within this research project denotes the general public that interacted with these works.

Using *QuickTime* media player and *Microsoft Excel* I coded each participants' interaction with the work using grounded theory techniques. I included anyone who had an interaction with the installation that I deemed significant. I used a variety of labels to keep track of the interactions on the video. Columns were headed:

- **Length:** Length of interaction. This reading was taken from the participant noticing to disengaging and walking away from the installation.
- **Age:** The approximate perceived age of the participant
- **Sex:** The perceived sex of the participant.
- **Comment:** My initial comments, interactions that stood out, games that were played, collaboration with other participants, etc.
- **Theremin:** Did the participant interact with the 'Plant Theremin' part of the installation.
- **Photos:** Did the participant take photos/ video of the work.
- **How Does It Work?:** Did the participant ask Cayn or myself how the installation was created or the technology behind the work?
- **Timecode:** I used this column as a quick reference to review observations made in the video.

Modes of Interaction:

Preliminary interaction modes were developed from general observations of the *In Touch* installation. These preliminary interaction modes were used to code participants' behaviours within *The Plants*. As noted in chapter seven these modes of interaction were deemed too simplistic as they assume that an observer will

necessarily become a participant. They are described here to illustrate the evolution of my understanding of participants' behaviours.

- **Watcher:** Did the participant predominately stand and watch the interactions of others?
- **Tapper:** Did the participant predominately 'tap' the interface in a disengaged/disinterested way?
- **Player:** Did the participant begin to 'play' the interface either melodically or rhythmically?
- **Banger:** Was the participant forceful with the interface?
- **Teacher:** Did the participant teach others how to use the interface?

These modes will be discussed further and refined in chapter seven.

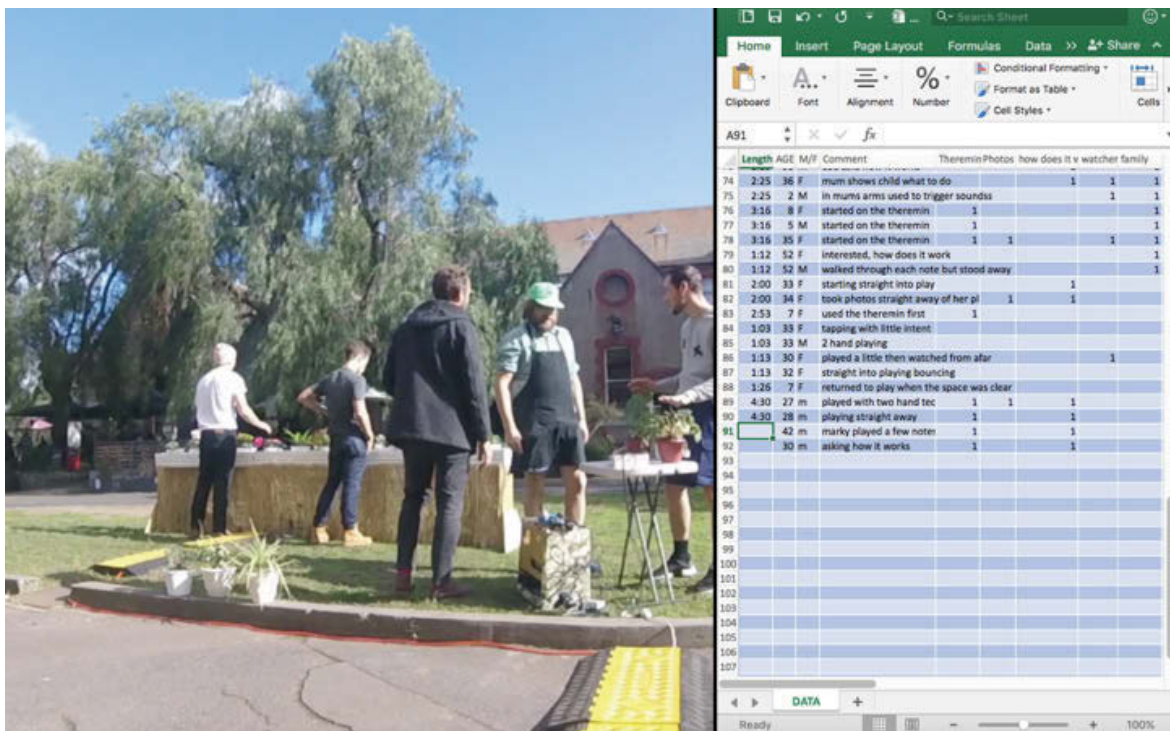


Figure 42 - The split screen view of my video observations.

6.2.2 Secondary Resource: Collaborator Interview

After I had analysed the first hour of the footage described in the previous section I interviewed my collaborator, composer Cayn Borthwick who worked on both *In Touch* and *The Plants*. The interview was held over Skype on July 26, 2017,

approximately 9 weeks after the completion of *The Plants* installation. I felt that it was important to have some time between the work and the interview to allow for ideas to ruminate. I also wanted to reflect on the video footage before interviewing Cayn.

Below are the questions I asked and the most pertinent observations from the interviewee:

Interview with composer Cayn Borthwick

G - “Anything that springs to mind when you think of the works?”

C - “It was fun... I was intrigued by how interesting people found it... I’m constantly amazed at how much people are, kind of struck to wonderment by the thing... I don’t know if that’s just because I’m used to it... People’s minds are always blown that you can do the touch thing and it makes a noise.”

G - “You used phrases but also individual notes and sound effects?”

C - “It was interesting to see what I thought would work not work and actually what ended up working and not working... It seemed like a lot of the time simpler sounds and, just fun sound effects are more effective... I suppose I imagined in my head that people would string together these crazy phrase books like samples but they kind of didn’t... (but) they really got past that initial “ooh... this makes a sound what does this one do...” I’d like to somehow encourage that more going forward (where) people actually play them.”

G - “Making them out to be more like an instrument?”

C - “Yeah, taking that next step I think past the discovery phase.”

G - “In *The Plants* you used a certain scale didn’t you, what was that called?”

C - "That was a good experiment for me actually, so I used a scale based on the harmonic series, because at the time when we were doing that I was researching a lot in spectral music, spectral music is pretty much made from spectrograms or analysis of sounds. The idea is that because your modelling off what is already there by nature it should sound good... The idea behind using that set of frequencies no matter what you hit it should sound good... It's got more of a Lydian dominant vibe to it if you want to get all modal about it... The intervals are tonic, 5th, tonic, 3rd, 5th, tonic, 2nd, 3rd sharp, 4, 5th that was I think all of them."

G - "*In Touch* I think it was a pentatonic or major?"

C - "It was either pentatonic or major I think... I suppose what was good about that was that those people who could play a bit of piano and stuff when they tried to play the flowers they were expecting to be a bit like that (major chord notes) and took them a lot to work out what was going on, not so easy for them to perform something (on the scale based on the harmonic series)... *In Touch* was the normal major or pentatonic and just licks based around that as well"

In this next section, we discussed preliminary modes of interaction:

G - "Did you recognize the 'casual tapper' – disinterested, confused, shy."

C - "Oh definitely yeah. The casual tapper I think that comes with like people's personalities?"

G - "What about the focused player - finding games within the work, doesn't need much encouragement, tuneful, rhythmic, serious."

C - "There were a couple of people that were already musos... There is also the other adult one who is stand offish, they come up and they do it, test it out then they just want to know how it's doing its thing... It was more focused (in *The Plants*) because we had the instrument it was just about this instrument thing... Whereas *In Touch* it had that visual dynamic where it was more spread out and people were more spread out."

G - “And I have another one, the ‘Un-focused banger’ they’re loud a-rhythmic, not tuneful, energetic, silly, fun.”

C - “In both (*The Plants* and *In Touch*) definitely... Definitely a common group and often a young child”

G - “Often about hearing one note sort of thing?”

C - “Yeah... There is a tactile difference there in the way that people interact with (*The Plants*) as opposed to the other one (*In Touch*) whereas (in *The Plants*) they are playing, it’s a finite instrument whereas in the other one (*In Touch*) they are like does this one work does this one work? It would be interesting to work out if you could put a little bit of code in the boxes that logs the touches”

G - “We had a few plant problems?”

C - “Aesthetically we didn’t predict how quickly they would just get mutilated”

G - “Is there anything else you would like to add?”

C - “If we were working in that format with the plants... Say we had 5 of those single things built so there were ways you could set them up so people could be playing two at once... I think the shapes you could make and then have people in playing them would be cool... The possibilities we already spoke of possibilities for having moments of experts who come in and do a thing... people like you or I have rehearsed how to play a song”

G - “Do you have any general comments?”

C - “In general it definitely gets people interacting, like it’s supposed to.”

Discussion

This interview with Cayn brought up a few common themes.

There is a 'wonderment' that people have when they first realise that they can touch the plants (or conductive paint in the case of *In Touch*) and trigger sounds and music. This could influence the 'fun' criterion in my preliminary design criteria. This initial wonderment could also be an 'attractor' as described by Edmonds (2006).

Simpler sounds generally worked better as people got past the wonderment stage and wanted to do 'more' with the installation. This could influence the 'control/agency' preliminary design criterion as it seems to be important to add complexity to keep people engaged.

The Plants is a finite instrument, 12 notes only, this created limitations for participants. The scale chosen (a collection of tones based on the harmonic series) may have been too complicated for people to 'play' the installation like an instrument. The interaction mode 'player' would have been effected by this decision. We may have seen the 'player' mode more if the scale had been different. Perhaps in the future we would lean towards more widely used scales such as major or pentatonic as used for *In Touch*.

Some of the plants were problematic as they didn't all hold up to some of the more forceful participants. This issue would definitely be a strong consideration in the future, using organic materials will not last very long especially around younger children.

Cayn suggested that it might be good to add a performative element such as having professional musicians play musical pieces with the work. This would offer the observer a demonstration of the functionality of the installation and could also serve as an 'attractor'. He also suggested scaling up the work and that more space to play in would be good.

He also suggested that it would be good to log the touches to get data. That is a great idea to trace interaction in a more quantitative way.

Generally, the preliminary modes of interaction (tapper, player, banger, teacher) were witnessed. These modes will be discussed more after the video documentation has been analysed.

6.2.3 Field Notes and Recordings

Cayn Borthwick and myself were present for the majority of *The Plants* installation, many of our real-time observations were discussed at the end of the day. Below is a summary of my field notes, full notes can be found in appendix C.

The field notes point to the importance of planning and time management issues in the development phase of *The Plants* installation. It also observed that the installation would benefit from being larger to accommodate 20 – 30 participants at a time. The field notes outlined some specific interaction with participants that had physical disabilities illustrating the importance of accessibility of the installation. Other accessibility issues such as the observation that participants overwhelmingly accessed the installation from one side (the side facing the pavement). It was observed through listening back to audio recordings of the work that whilst the sonic output was often chaotic the overall output was pleasant due to the scale used. Future iterations of this work should focus on collaboration between participants. The field notes also indicated that participants were curious about how the installation worked as many participants would ask how the technology functioned. Finally, it was noted that the piano setting was by far the most popular setting in the work.

6.3 Video Documentation Observations

I reviewed a total of four hours of footage, tracing each interaction by participants. There were 368 interactions with the work in four hours, approximately 12 of these were repeat interactions by single individuals. The participants ranged in age from approximately 1-year-old to 80 years old. This level of engagement was deemed successful by both the Abbotsford Convent staff and the collaborators involved in the work.

General observations are outlined below:

Child-specific observations (approx. 12 and under)

- I witnessed a few participants dancing while interacting with the plants, often incorporating their playing into their dance i.e. bobbing up and down while holding out a hand to play the plants with.
- Multiple children returned to the work with new ideas to try.
- Children from different families often worked together and showed each other how particular parts of the work functioned.
- Children would often show adults how to interact with the work.
- Many children had a predilection for walking up and down the line of plants making sure they touched each one in turn. This task-based interaction was also observed in some adult participants.
- Children aged approx. 1 – 4 could not reach the plants and were held by their parents so that they could touch the plants.
- Children would bring their parents to the work to interact together.
- Some children hit the plants quite hard resulting in some smashed plants.

Adult specific observations (approx. 13 and over)

- A lot of participants liked to film themselves interacting with the work, often viewing the entire experience through their smartphone. This was limited predominately to 20 – 35-year-olds.
- Parents would usually watch their children play but not interact with the work themselves.

General observations

- The artists (myself and composer Cayn Borthwick) looked as if we needed more to do. We were often standing around, sometimes fielding questions about how the work functioned. At some points, we would break into spontaneous play, these moments often attract new participants to the work.
- Generally, people started warily as observers before joining in.
- Sometimes adults followed children to play, sometimes children followed the adults.

- Sometimes participants would be forced to stay in one place and did not experience the range of notes available as the line of plants would sometimes become congested.
- Some would leave and then come back when the installation was less crowded.
- Some people would stay for a long time and shift between observer and participant.
- Many 'looks' were encountered during the installation ranging from, joy, confusion, fascination, wonder to blank stares.
- Extended engagements (longer than 3 minutes) usually came with a conversation with either myself or Cayn
- When both Cayn and I left the area, there was markedly less interaction with the work by participants.
- Some younger participants (approximately 4 years and younger) had trouble reaching the plants. Often parents would lift their children and effectively 'play' the interface with their child.
- Some older people who actively 'played' the work like an instrument didn't stay very long.
- Often parents showed the children how the work was to be interacted with, but sometimes children took the initiative to teach parents and other children how to play the plants.
- People generally play one note at a time (rather than trying to play a chord with both hands)
- Some people would hover their hands over the plants until a sound would trigger, they were unwittingly testing the thresholds of each trigger.
- The music created by participants of this work could best be described as 'Minimalist Music'. As the notes cascaded, slowed, sped up and repeated I was reminded of the music of minimalist composers such as La Monte Young, Steve Reich, and Phillip Glass.
- Most people were gentle with the plants, some children were a bit rough resulting in some damaged plants.
- Generally, people start slow and build confidence over time.
- People who just stand and watch generally engage for a shorter time.

- 35.6% of people used the 'Plant Theremin' device (usually when the installation was busy).
- One of the biggest obstacles to interaction was the size of the work and simply the amount of opportunities that participants had to play within their own space (as witnessed more successfully in the *In Touch* exhibition).
- Most watcher/ observers would eventually take their hands out of their pockets and give *The Plants* a try.

Some individual interactions often defied crowd behaviour but were fascinating and often completely unexpected. I will outline some examples of this below:

- One girl (approximately six years old) created a method of composing her own musical pieces by writing a pattern in her colouring book that I was unable to decipher. She ran from plant to plant playing a complex series of notes (including the plant Theremin). She interacted with the plants between writing her compositions in her colouring book for over 6 minutes.
- A girl (approximately five years old) created a very angular dance that was accented by playing the plants in time with her movements.
- One boy (approximately eight years old) had perfect pitch and could correctly guess the pitch of each plant. He returned multiple times to play.

Observations (relating to specific age groups)

The age groups chosen here reflect patterns that emerged during the observation of the video documentation.

1 – 4 Years (48 interactions. Total interaction time: 2 hr. 07 min. Average interaction time 2 min 39 secs.): These participants were generally too small to reach the plants, this resulted in a family member holding the participant to interact with the plants.

5 – 8 Years (57 interactions. Total interaction time: 3 hr. 10 min. Average interaction time 3 min. 21 secs.): The most return participants, multiple engagements and the longest average interaction time. Often participants in this age

group would take on a 'teacher' role, they were very active in showing others how to engage with the installation. The broadest range of interaction modes were witnessed within this group.

9 – 14 Years (13 interactions. Total interaction time: 50 hr. 26 min. Average interaction time 3 min. 53 secs.): These interactions were generally more confident; this group is more interested in how the device works and often stay to chat with the facilitators.

15 – 21 Years (10 interactions. Total interaction time: 23 hr. 58 min. Average interaction time 2 min. 42 secs.): This was a small group (10 individuals) It would be interesting to discover the reasons that this group wouldn't want to interact with this work. Does it have to do with social awkwardness or some other factor?

22 – 30 Years (61 interactions. Total interaction time: 3 hr. 11 min. Average interaction time 3 min. 08 secs.): A lot of photo taking with smartphones in this group. Often participants in this age group interacted as part of a group. Musical interaction between friends was observed in this group.

31 – 40 Years (124 interactions. Total interaction time: 5 hr. 18 min. Average interaction time 2 min. 34 secs.): This age group mostly involved parents playing the plants with their children.

40 – 50 Years (36 interactions. Total interaction time: 1 hr. 41 min. Average interaction time 2 min. 49 secs.): This group would often stand back and watch before interacting with the work. They were often led by other younger participants.

50 – 80 Years (17 interactions. Total interaction time: 41 hr. 50 min. Average interaction time 2 min. 28 secs.): This group was pretty evenly split between active players and passive observers.

Below are some more observations relating to the coding of the video:

- **Photos:** As mentioned above predominately this was observed in participants aged 22 – 30 years. (10% of observed interactions included filming/ photographs)
- **How Does It Work?:** Both adults and children were curious about how *The Plants* installation worked. This often happened whilst the participant kept playing. (21% of participants asked how it worked)

Modes of Interaction:

- **Watcher:** Especially within adult groups (over 35) many participants stood and watched the play of younger participants. (17% of all participants were categorized as ‘watchers’)
- **Tapper:** Whilst some participants were very ‘musical’ and rhythmic, many participants would simply touch each plant to discover what the effect was and that would be the end of their interaction. (29% of all participants were categorized as ‘tappers’)
- **Player:** Many participants could be considered ‘players’ as they interacted with *The Plants* as if it was a musical instrument, sometimes creating complex patterns and riffs. (20.6% of all participants were categorized as ‘watchers’)
- **Banger:** Some participants were forceful with the interface, resulting in some damage to the relatively fragile plants. (3.3% of all participants were categorized as ‘bangers’)
- **Teacher:** This was mostly observed in younger participants who instructed others on how to engage with the installation. (4.35% of all participants were categorized as ‘teachers’)

6.4 Discussion

Now that I have outlined the primary study of *The Plants* I will discuss some of the participants' behaviors, experiences and the common themes which will help me develop the design criteria in chapter seven.

6.4.1 Invitation

One of the most important findings from this research project is the discovery of the observer to participant journey and the invitation to interact. Most works studied in my literature review were undertaken in controlled environments where participants knew that they were going to interact with an artwork ahead of time. The participants studied here were not necessarily going to interact with an interactive touch-based musical installation. Therefore, the reasons that they move from observer to participant is of utmost importance.

Turning Observers into Participants

A big question for all interaction designers and artists is how do you turn an observer into an engaged participant? Participants here are defined as having a physical experience with the installation. Often the first interaction would come without specific intention. This was observed as participants learnt through watching others playing the plants, then tentatively playing themselves. 'Engagement' as described in Hall and Bannon (2005) recommends that children should be motivated to participate, this is true of participants of all ages, but how do we facilitate this engagement?

Adults in particular, could sometimes be wary to engage with the installation, especially young adults aged 15 – 21. This could be happening for a number of reasons:

- Social awkwardness.
- Thinking that the installation is only for kids.
- Seeing the installation as too simplistic, i.e. being an observer is just as good as being a participant.

Quite often children would be the instigators of engagement as they pulled their parents (sometimes literally) to the installation and would encourage their parents to play. The reverse of this, adults bringing children to engage with the work would also occur. This is a phenomenon also noted in the *Polymetros* studies which found that family or friends influence both engagement and disengagement from an interactive work (Bengler & Bryan-Kinns 2013, 2015).

The public setting for *The Plants* meant that participants were often able to witness others engaging with the work before they did. This affected the ‘adaptation’ (Bilda, Edmonds & Candy 2008) period as participants got an idea of ‘how’ to interact before they actually would interact. Engagement was a combination of their observations and their physical experience. Therefore, it is important for the installation to be visible to observers, it encourages an observer/ participant ‘feedback loop’ inviting others to play, which in turn invites others to play.

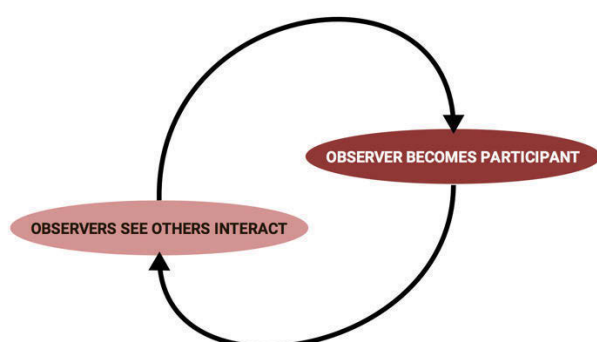


Figure 43 – The participant – observer feedback loop

It should be noted that once an observer had become a participant they were likely to shift between these two modes: observer and participant.

The journey from observer to participant will be addressed within the design criteria in chapter seven.

Wonderment & Curiosity

Collaborator Cayn Borthwick spoke of participant's being "struck to wonderment" by the fact that they could use their skin to activate music. Observations show that this wonderment and curiosity is a strong 'attractor' which achieves the most important goal of inviting observers to become participants. This is closely related to the 'discovery' mode in Costello & Edmonds' pleasure framework (2007) as participants discover how the installation works on their own, by asking myself or Cayn, or through collaboration with another participant.

In *The Plants*, we play with perception and expectation. The installation was instantly abstract as participants play piano by touching living plants. The 'magical' nature of the work comes from challenging the functional fixedness of an object such as plants which illustrates the pleasure of 'subversion' (Costello & Edmonds 2007).

Curiosity is also discussed by Hall and Bannon (Hall & Bannon 2005) as a way to sustain engagement. This is similar to 'sustainers' (Edmonds, Muller & Connell 2006) and was observed in *The Plants* especially within the 5 – 14 age group. This age group stayed with the work the longest and generally made sure they interacted with every plant in the installation.

Turning Participants into Return Participants

Most participants would shift between observer and participant many times within one visit. On some occasions participants would make a return visit to the installation. This happened for a variety of reasons:

- Sometimes a participant's family would be around the Abbotsford Convent area so they would bounce back and forth between family and the installation.
- The participant had created an elaborate game (such as the girl with the mystery compositions).
- The participant wanted to become a kind of instructor and teach others how to play.
- The participant wanted to ask Cayn or myself how the installation worked or just have a general conversation.

- Some participants would return when the installation was less crowded so that they had more space to play.

6.4.2 Interaction

Once people move from observer to participant by interacting with the installation they enter the 'Learning' phase as outlined in (Bilda, Edmonds & Candy 2008). Hall and Bannon state that engaging interactive experiences 'facilitates both individual and group interaction: there should be support both for individual and collaborative endeavor' (Hall & Bannon 2005). *The Plants* was developed as an installation that could be experienced collaboratively or as a solo experience, these emerged as two distinct engagement types. Ways that participants interact with the work and with each other will be discussed here.

Solo Play

Solo play not surprisingly denotes interactions of solo participants. The size and intimate nature of the installation meant that this was not an overly common occurrence. Even those that intended to play solo were forced into a kind of collaboration when others engaged with the installation (see unintended collaboration below).

Inventing Games

This was evident in the example of the girl who created a composition system by writing in her notebook or the boy with perfect pitch who came to guess the notes that people played.

These games suggested there was a deeper understanding of how the interface worked. Participants who created games would engage with the work for longer periods and often return over and over to develop their game.

Dance Moves

Dancing also formed a kind of game within the work as younger participants (approx. 5 – 8 years old) created dances that would become part of their engagement with the installation. This was observed as dancing that facilitated play (i.e. bobbing up and

down touching the plants) or dancing near the installation, reacting to its musical output.

Controlled Exploration

This is a broad category that includes the games and dance mentioned above but also any interaction deemed 'controlled'. Many participants would walk up and down the row of plants in a deliberate fashion to activate each plant and discover the sonic boundaries of the work. This was observed mostly in interactions by children but also sometimes by adult participants. This could fall into 'Deliberate or Intended/ In Control mode' ([Bilda, Edmonds & Candy 2008](#)). Another example of this includes testing the triggers by holding a hand just above a plant and lowering it slowly to work out when it would trigger a sound.

Collaborative Play

'Collaboration between children and their significant others, is critically important in children's inter-subjective development' ([Hall & Bannon 2005](#)). Collaboration is one of the main goals of this work. We want to get people engaging with each other in a variety of ways. I have broken this into the four observed types of collaboration: teacher – student collaboration, musical collaborators, parent/ guardian - child collaboration and unintended collaboration.

Teacher – Student Collaboration

The 'discovery mode' ([Costello & Edmonds 2007](#)) or 'Learning' phase ([Bilda, Edmonds & Candy 2008](#)) is experienced both individually and collaboratively within this work. An interesting phenomenon of participants teaching other participants how to engage with the work emerged. This was observed in four different modes:

- Adults teaching children.
- Children teaching adults.
- Children teaching other children.
- Artist teaching participant.

This suggests that the work was mysterious enough in nature that it had to be 'taught' to another participant. It also meant that the moment of discovery was strong enough for people that they wanted to share it with others. The fourth mode of 'artist

teaching participant' was used sparingly as we were careful not to be too prescriptive, we wanted the participant to have their moment of discovery.

Musical Collaborators

Musical collaboration was observed especially among participants that were in groups of friends aged 22 – 30. Sometimes participants with some musical knowledge instigated collaboration with strangers that were next to them, recruiting them into their compositions. This musical collaboration was also witnessed between the facilitators and other participants.

Parent/ Guardian - Child collaboration

I observed many parents/ guardians playing music with their children. Children aged approximately 1 to 4 years were too small to reach the plants so they were lifted and held by their parents to play them. These interactions demonstrates Costello & Edmond's pleasure of camaraderie: 'Camaraderie is the pleasure of developing a sense of friendship, fellowship or intimacy with someone.' (2007). Camaraderie was also demonstrated in children of different families working together independently. Older children would also collaborate with their parents and other participants, although sometimes this could be seen as an 'unintended collaboration'.

Unintended Collaboration

In *The Plants* participants were often shoulder to shoulder or reaching over one another to play music. They may not necessarily acknowledge others around them also making music but it seemed to affect the experience of that participant. The overall soundscape created by the installation was often a product of this unintentional collaboration.

Play Techniques

As *The Plants* installation was essentially an instrument with twelve notes a variety of novel techniques were developed by the participants. These play techniques were witnessed in participants both as solo players and collaborators.

The techniques utilised by participants looked to be influenced by ‘Sensation’ (Costello & Edmonds 2007) as participants enjoyed touching the plants but had to adjust their playing style according to their delicate nature.

Generally, we found that participants would play one note at a time rather than playing two (or more). We witnessed the one hand tap, the two-hand coordinated movement, and the arms cross movement. Participants would get more confident over time and experiment with these different playing styles.

Some participants would play ‘through their phone’ filming as they engaged with the work. This technique of playing with the installation was definitely a novel approach to music making. It should not be surprising that this happens or that the phenomenon is seen mostly in participants aged approximately 20 – 35.

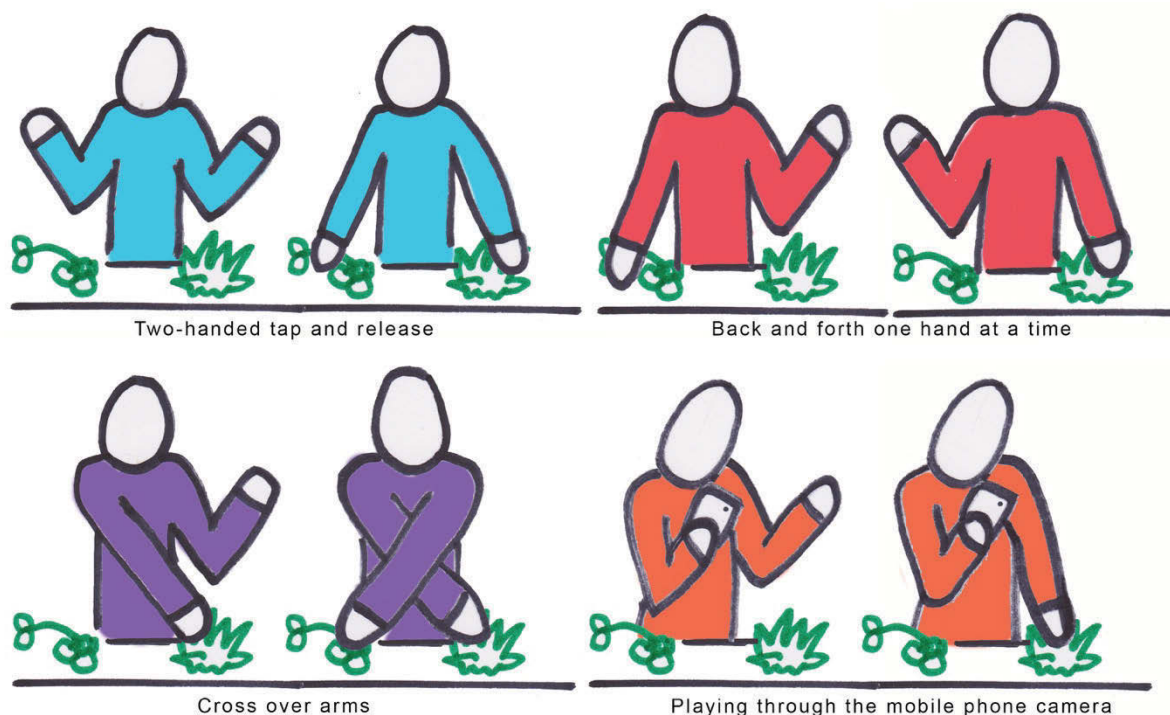


Figure 44 - Demonstrations of some play techniques.

Some participants would stay in one place triggering the same sound over and over, generally, this occurred when the installation was too crowded for free movement.

6.4.3 Design

Complexity (and Simplicity)

'A work may be trying to arouse pleasure in creation but this pleasure will not be felt very strongly if the things that the participant can create are not perceived to be either novel, surprising, or complex or unexpected.' ([Costello & Edmonds 2007](#)).

In *The Plants* added levels of complexity were introduced over time as the instrument cycled through sound banks (piano, synthesizer, bird sounds). But as noted the piano was by far the most popular 'instrument'. This meant that whilst there was an option for heightened complexity participants seemed to prefer a simple series of sounds so that they could explore and play distinct individual notes in that limited sonic space.

As suggested by composer Cayn Borthwick, in general, simpler sounds and sound effects were more effective than complex patterns. Also, whilst the scale used for *The Plants* (based on the harmonic series) was pleasing to the ear its complexity made it more difficult to 'play' like an instrument. A major or pentatonic scale would make it easier to play a familiar tune but it would also make the installation sound more 'simple'. The harmonic series scale also led to the work having a unique sonic palate reminiscent of minimalist compositions.

'Multiple levels of engagement' ([Hall & Bannon 2005](#)) are recommended to keep participants engaged. The popularity of the 'Plant Theremin' experiment that was part of *The Plants* installation indicates that variety is effective to keep participants engaged in the space.

Big Versus Small

The Plants was a much smaller installation than the pilot study *In Touch* which took over a whole gallery. The smaller installation area of *The Plants* meant that there seemed to be 'unintended collaboration' between participants as they were close to one another to play the instrument. Cayn and I have discussed scaling up *The Plants* so that there are 5 sets of 12 plants. Each set of plants would trigger a different instrument within a chosen scale. This would allow us to keep the simplicity of the

work but add complexity by expanding the sonic palate. Scaling up would also address the issue of people only being able to play a limited amount of plants at a time as noted in 'play techniques'.

As with any installation the physical environment must be considered in the design phase. In *The Plants* the outdoor location meant that participants were already familiar with the environment. As the interface was made up of living plants and we were in a very natural setting the work blended very well with the surroundings. The installation felt organic and non-threatening and participants felt that 'the exhibition space is an inviting place' ([Hall & Bannon 2005](#)).

Technology Improvements

Hall and Bannon recommend that the 'experience integrates computing' ([2005](#)) suggesting that the technology utilised for an installation should be hidden. In *The Plants* the computing and sound devices were hidden under the planter unit. Some of the technology we were unable to hide such as the button that changed the sound bank or the wires that came out of the plant pots. Having some elements of the technology on display can also be a good way to engage participants in a conversation about the work (as discussed more below).

It would be interesting to use the modulation available with technology described by Muller ([2011](#)) integrated with the simple instrumentation discussed here. For example, could the amount of skin that a participant used to trigger a note also control the volume, sustain or modulation of that note? This may be possible with 'Swept Frequency Capacitive Sensing' technology proposed in *Botanicus Interacticus* ([Poupyrev et al. 2012](#)).

Performance and facilitation by attending artists

In both installations studied here the attending artist(s) have been relatively passive facilitators answering people's questions and sometimes demonstrating how the installation works. We experimented with being present and facilitating interaction as well as leaving the work unattended to see if autonomous engagement would occur. We found that there was less engagement from participants when the installation was unattended.

Whenever we would improvise on the plants we would draw new participants in to engage with the installation. This could be because without music being produced the installation is quite visually unassuming (simply plants on a stand). When the installation was not being 'played' by participants Cayn and I could have been performing music on the installation with the intention of inviting others to come and join in. Cayn Borthwick suggested that we could rehearse a musical piece on the installation and perform this piece whilst the installation is empty.

The workshops that featured as part of the *In Touch* installation allowed for a more performative approach as we played games in the space. These games introduced the participants to the possibilities of the installation that they could explore further during 'free play' at the end of the workshops.

I believe that it is important for participants (especially children) to be able to ask questions about the technology and have the work explained if they are curious. 21% of participants asked how it worked and extended engagements would often come with conversations between participants and Cayn or myself.

Sound

As mentioned in 'Complexity and Simplicity' the scale chosen by Cayn Borthwick based on the harmonic series was both pleasing and problematic. Aesthetically the scale was commented upon by passersby as being pleasant. Even after reviewing approximately two hours of recorded audio the scale didn't get old.

The scale was also problematic as it made the installation hard to play. A simpler major or pentatonic scale would have allowed musicians to play a tune but also would have effected 'playability' for the non-musician. This scale allowed for 'sonic chaos' i.e. when a participant was erratically playing, the soundscape was still interesting to listen to.

In *The Plants* we wanted people to 'play' the installation so we decided to offer individual notes or sounds to the audience. The choice of sound will depend on the intention of the work. If it is to act as an instrument obviously, it is better to have

individual notes in some sort of sequence, if a narrative is required sound effects and spoken phrases may be more appropriate (see chapter eight: Sounding Stories).

Playability

The future focus of *Playable Streets* will be to create installations that are more 'playable' this will mean striking the right balance between complexity and simplicity of the sounds chosen as discussed in the previous section.

Children aged 1 – 4 had trouble playing the installation because of its height. This could be remedied by making the platform that the plants sit on lower. This would also have the effect of stopping the phenomenon of adult lifting children to play which was often quite comical.

Some musicians engaged with the work but didn't stay and interact for long periods of time. Could this be because the work is too limited or too easy or are they confused by the scale used? One of the biggest challenges is creating installations that cater for musicians and those that want to be challenged, at the same time keeping a low level of entry, especially for younger participants. Whilst the installations are not necessarily created specifically for musicians this should be taken into consideration. Playability is also reliant on the consistency of the installation which will be discussed in the next section.

Consistency

Once participants had discovered how the interface worked they expected each plant to work in a similar way. This anticipation was sometimes frustrated as some plants took more skin contact to trigger sounds. The 'Anticipation' mode ([Bilda, Edmonds & Candy 2008](#)) suggests that the reliability of the interface will allow participants to gain confidence and move onto deeper stages of interaction.

We also had some problems with the plants holding up structurally to continuous interaction by participants. This would be a problem with using any organic matter as an interface and should be taken into consideration in future work.

Accessibility

The issue of accessibility is an important consideration, the research brought up some interesting insights to consider. Some younger children couldn't reach the plants on their own but this encouraged collaboration with a parent/ guardian. Physical considerations such as the height of the sensors will determine the age range of potential participants. Although *The Plants* could be accessed on both sides it was only accessed on one side. The environment that the installation occupies will determine the flow of participants to the work. This needs to be considered in the design phase of the work. Multiple participants with physical disabilities were able to engage with *The Plants*. Further research is needed to develop greater access for participants with disabilities within public installations.

6.4.4 Better Evaluation

How can I create more time to step back and do more documentation/ evaluation of the work? One of the main lessons I have learnt in this process of research is that time is the most important element in a successful evaluation. I have strived to document as much as possible. A strategy that worked well for *The Plants* installation was to have a *Go Pro* camera set up and filming as much as possible. This footage became the basis of my evaluation of the work as I was able to track each participant's experience and behaviours.

I have also found that participant surveys aren't an ideal form of evaluation, especially with children. Some children had problems filling out the surveys and this resulted in them being filled out by their parents. If I was to use surveys in the future I would only use them as a secondary resource to corroborate observations from video documentation.

As discussed in chapter four 'video-cued recall' may be useful for future evaluation. It has been proven to help participants articulate their experiences ([Omodei & McLennan 1994](#)) and would be helpful to discover the reasons observers become participants. This would require access to a controlled space away from the installation to recount their experiences.

There was a suggestion by Cayn Borthwick to add a data logger to the *Raspberry Pi* so that it can log the actual number of touches from participants. This would be a useful quantitative evaluation tool. There are plenty of products and tutorials⁴⁸ online that cover how to do this.

6.5 Conclusion

In this chapter, I have summarized the methods used to research *The Plants* at the Abbotsford convent May 20 and 21, 2017. This included video documentation in which individual participants' experiences and behaviours were tracked and coded. I presented an interview with my collaborator, composer Cayn Borthwick and discussed key findings from this. I have also noted findings from my field notes and audio recordings.

General observations from the video documentation have been outlined as well as those related to specific age groups. Finally, in the discussion of these observations I have highlighted participants' experience and behaviours. I have exposed common themes relating to both interaction and design of the installation. I have also discussed ways of developing my research method.

In the next chapter, I will use these observations to amend my preliminary modes of interaction and design criteria.

⁴⁸ https://www.youtube.com/watch?v=_phBLvAPIE0

7. A Design Framework for Interactive Touch-Based Musical Installations

7.1 Introduction

This design-based research project has produced a series of interaction modes and design criteria that have evolved throughout the development of two interactive touch-based musical installations. The preliminary design criteria laid out in section 5.5 will be refined from the observations described in chapter six.

In this chapter, I will revise the preliminary modes that were used to code the interactions of participants in *The Plants*. I will present an engagement model that acknowledges the journey of the observer to participant. Finally, I will present design criteria based on this engagement model.

7.2 Engagement Model

As discussed in chapter six, modes of interaction only come when an observer becomes an active participant in the work. Therefore, I have included the journey of the observer to participant in this engagement model.

The initial modes of interaction chosen to code the video and used in the interview with Cayn Borthwick will be revised in this section. The interaction modes of 'Watcher', 'Tapper', 'Player', 'Banger' and 'Teacher' were observed within the study but deemed too simplistic. Also, they assume that an observer will necessarily become a participant. I will propose that there are two main modes of interaction: solo play and collaborative play and show that each mode contains a subset of interactions.

Observer to Participant Journey

Within the research, I witnessed a 'journey' that began with observers becoming participants, who then move through a series of interaction modes.

Observers become participants through 'invitations' which include:

- Friends and family
- Curiosity
- Artist/ Facilitator

Once the observer becomes a participant their 'journey' continues through a series of interaction modes.

Solo Play

Solo players may interact in a variety of ways utilising any number of play techniques described in chapter six.

Solo players are more likely to:

- Invent musical games.
- Create dance moves facilitated by play or in reaction to musical output of others
- Undertake controlled exploration: i.e. walking up and down making sure to trigger every note.

Collaborative Play

Collaborators can obviously use the same play techniques as solo players but they use them with and around other participants.

Often participants will shift through these modes of collaboration:

- Teacher - student collaboration
- Musical collaborators
- Parent/ guardian – child collaboration
- Unintended collaboration

A solo player will often become a collaborative player as the plants are interacted with by another participant. Collaborators will become solo players as others leave the installation. Participants will also switch back and forth from observer multiple times within a single interaction.

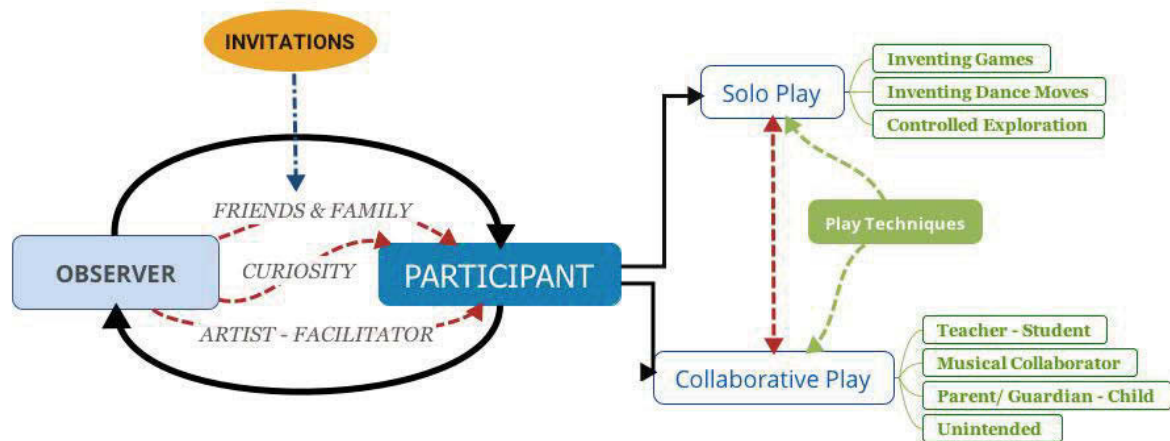


Figure 45 – Interactive touch-based musical installation engagement model.

7.3 Design Criteria

Preliminary Design Criteria

The preliminary design criteria were created in response to the findings of the pilot study: *In Touch* before the observations had been made from *The Plants* study. *The Plants* observations developed a more comprehensive understanding of the ways that people interact with this installation. Also, it is important to note that *In Touch* and *The Plants* were presented in different environments under different circumstances so this may account for the dramatic re-imagining of the preliminary design criteria:

1. **The installation should be accessible, encourage exploration and interaction. (Accessibility)**
2. **The user should feel like she/ he is responsible for creating the sound in the space with their touch. (Control & Agency)**
3. **The interface should be consistently responsive. (Consistency)**
4. **The installation should be fun. (Fun)**

Refined Design Criteria:

The refined design criteria have been created in reaction to the observer to participant journey and interaction modes of solo and collaborative play.

| Interaction Mode | Design Criteria |
|-------------------------|---|
| Observer to Participant | Create the installation in an area that can be easily seen by people passing by. |
| | Create a space that appeals to people of all ages as family and friends will invite others to the work. |
| | Decide on a performative task for the facilitator that will invite an observer to become a participant. |
| | Develop a sense of 'magic' and 'wonder', this will facilitate 'curiosity'. |
| Solo Play | Encourage musical games by adding layers of complexity in sound and technology. |
| | Create an installation big enough that a solo performer can explore the installation alone. |
| | Create an environment that has enough space for games to develop. |
| Collaborative Play | Create accessibility barriers to some participants' interaction (i.e. 1 – 4-year-olds) to encourage collaboration with parent/ guardian. |
| | Some technology on display (wires or buttons etc.) can encourage the 'teacher – student' collaboration. |
| | Decide on a performative task for the facilitator that will encourage musical collaboration. |
| | Create an installation with sensors that are close together to facilitate 'unintended collaboration'! |
| All Modes | Consider the accessibility of the space to encourage interaction by all age groups and ability levels. |
| | Make sure the technology delivers a consistent result to encourage exploration, interaction, collaboration and play. The user should feel like she/he is responsible for creating the sound of the installation with their touch. |
| | Sonic aesthetics (i.e. sounds chosen) will be up to the artist but consider the effect they will have on the participant. |
| | The sounds that the installation produces should be complex enough to create a pleasing sound but also be 'playable'. The sound should not be so complex as to disrupt play or hinder non-musicians. |

Figure 46 - Design criteria for creating interactive touch-based musical installations.

7.4 Conclusion

In this chapter, I have presented an engagement model that considers the observer to participant 'journey'. When an observer becomes a participant, they move between solo play and collaborative play interaction modes. The sub-sets of these modes have also been discussed.

From this engagement model, revised design criteria have been proposed to facilitate each interaction mode. These design criteria have been influenced by the observations in chapter six. It has also been influenced by the pilot study *In Touch* and the three frameworks discussed in chapter two.

This set of design criteria is intended to act as a guide in the design of interactive touch-based musical installations. They will probably not all be applicable and in some cases, may prove contradictory (i.e. simplicity and complexity or accessibility and restrictions within the space). Aesthetic or artistic decisions may render some of these suggestions unappealing and space restrictions may mean that some are impossible to achieve.

In the next chapter, I will discuss new works that have been influenced by this design criteria.

8. Applications of Design Criteria and Future Work

8.1 Introduction

In 'The Reflective Practitioner', Donald Schön states 'research functions not as a distraction from practice but as a development of it' (1984). I intend to use the insights developed in this research project to continue making new interactive touch-based musical installations with the company *Playable Streets*. At the time of writing this, the design framework developed here has influenced two new works *Reach Out Sounds* and *Sounding Stories*. It has also influenced a product in development for school workshops called *Clippy* which allows students to create their own touch-based musical works.

In this chapter, I will discuss these works and note their connection to the design criteria outlined in chapter seven. I will also discuss future research that I will be pursuing into cooperative inquiry.

8.2 Reach Out Sounds

The aim of *Reach Out Sounds*⁴⁹ is to bring people together in the joy of creating music, even if you have never picked up an instrument in your life. In this work, *you* become the musical instrument, touching another participants' skin triggers sounds that create an evolving musical work that is at once energetic, original and fleeting. This work is influenced heavily by experimentation mentioned in section 3.2 working with *Polyglot Theatre on Paper Planet*.

One observation from this research project was that people were interacting well with the device (i.e. the musical plants or conductive paint) but weren't interacting enough with each other. *Reach Out Sounds* is designed to address this issue as it only works if there is a collaboration between two or more people.

⁴⁹ <http://www.playablestreets.com/reach-out-sounds/>

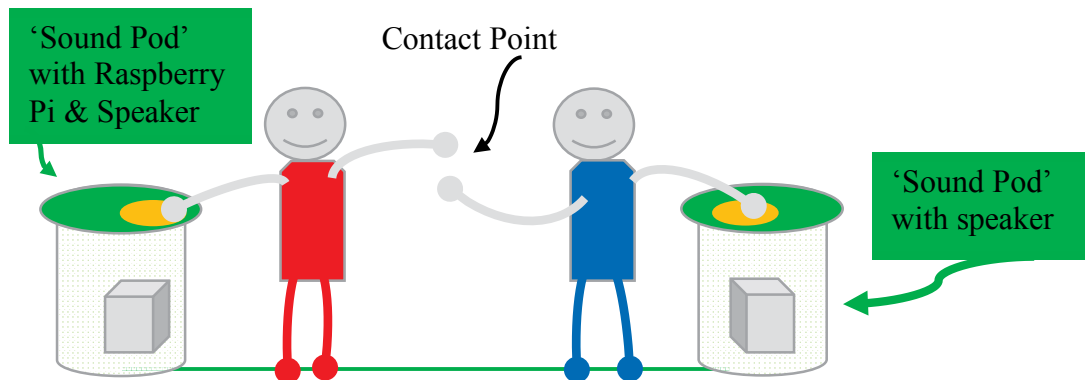


Figure 47 - Reach Out Sounds

This work has a strong focus on the interactive touch-based musical installation design criteria for collaborative play:

Create accessibility barriers to some participants' interaction (i.e. 1 – 4-year-olds) to encourage collaboration with parent/ guardian.

As the 'sound pods' that needed to be touched to activate the work were at least 5 metres apart they could not be triggered by one person alone. This created a barrier which encouraged interaction. Some pods were as far as 10 metres apart, resulting in a chain of people being required to activate the sounds.

Some technology on display (wires or buttons etc.) will encourage the 'teacher – student' collaboration.

Although there wasn't any specific buttons or wires on display, teacher – student collaborations did occur as children would teach adults or other children how to activate the music using their hands.

Decide on a performative task for the facilitator that will encourage Musical Collaboration.

Cayn Borthwick and I were present throughout the installation, we would assist solo players to make music. We would also encourage musical collaboration by asking some participants to create a beat on the 'drum pods' and have another group play music over that beat.

Create an installation with sensors that are close together to facilitate ‘unintended collaboration’.

As we only had a small space to install the work as part of the *Coburg Carnivale* unintended collaboration happened constantly. All participants could hear everybody’s musical contribution at varying volume levels.

Reach Out Sounds also addressed the Observer to Participant journey:

Create the installation in an area that can be easily seen by people passing by.

Reach Out Sounds was presented as part of the City of Moreland Council’s *Coburg Carnivale*, a street festival that takes over Victoria Street Mall (a busy walkway in Melbourne’s northern suburbs). We were fortunate to be situated in the middle of the mall, everyone that walked past could see and hear people playing.

Create a space that appeals to people of all ages as family and friends will invite others to the work.

As this work could only function with a minimum of two participants, we witnessed many people recruiting their friends and family into the music making. Often younger participants (aged approx. 5 – 12) would fall into collaboration with other children that they hadn’t met before to create music.

Develop a sense of ‘magic’ and ‘wonder’, this will facilitate ‘curiosity’.

Curiosity was a strong attractor in *Reach Out Sounds* as people passing by would notice that participants were making music simply by connecting with another participant. This curiosity would often turn an observer into a participant.

Decide on a performative task for the facilitator that will invite an observer to become a participant.

When the installation was empty, Cayn and I would improvise together to demonstrate the work to people passing by. This would act as a demonstration of the installation. We found that this was unnecessary for much of the time as other people would demonstrate the work as they played.

The design criteria for 'all modes' of engagement were also utilised:

Consider the accessibility of the space to encourage interaction by all age groups and ability levels.

In *Reach Out Sounds* all that is required to play is skin, therefore, it was accessible to all potential participants. We witnessed interaction by people of all ages. One elderly participant used their walking frame to making music as it could connect to others through their skin.

Make sure the technology delivers a consistent result to encourage exploration, interaction, collaboration and play. The user should feel like she/he is responsible for creating the sound of the installation with their touch.

This was a very important design goal for *Reach Out Sounds* we spent a lot of time on making sure it was very responsive and immediate. We also used eight monitor speakers in the 'pods' (two for each interaction area) to create an immersive sound experience. There was a strong correlation between a participants' touch and a sound.

Sonic aesthetics (i.e. sounds chosen) will be up to the artist but consider the effect they will have on the participant.

We decided to offer a different instrument on each set of 'sound pods' these included piano, drums, double bass and xylophone. Again, we noticed that the piano was the most popular (followed by drums). With a wide range of sounds available for experimentation this work allows participants to experiment much more than in *The Plants* installation.

The sounds that the installation produces should be complex enough to create a pleasing sound but also be 'playable'. The sound should not be so complex as to disrupt play or hinder non-musicians.

This was a big design challenge for *Reach Out Sounds* as we wanted participants to have more control over a variety of sounds but at the same time not create complete musical chaos. Participants could trigger a single note or up to three notes at the same time depending on the position of their hand on the 'sound pod' this would

sometimes create dissonance but it also created variety and a sense of control in the music being created.

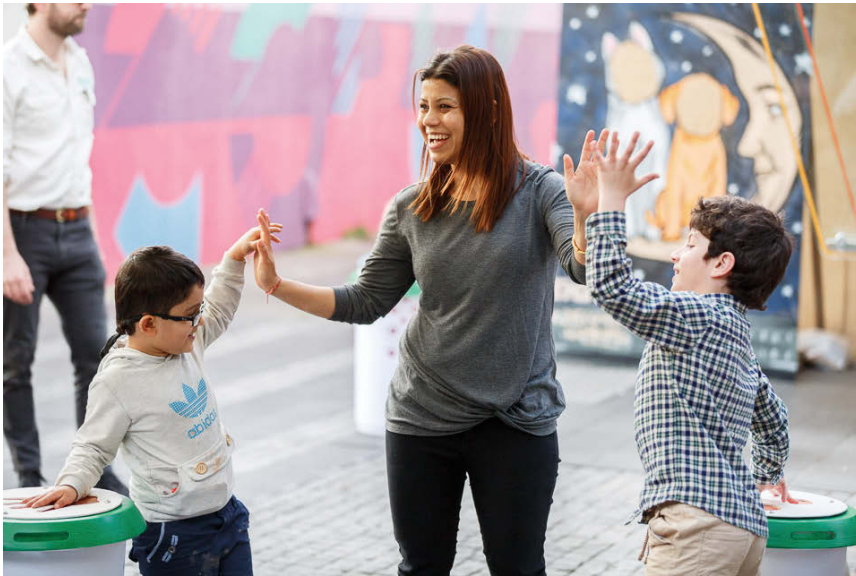


Figure 48 - Reach Out Sounds at the 'Coburg Carnivale' 2017.



Figure 49 - Reach Out Sounds at the 'Coburg Carnivale' 2017.

8.3 Sounding Stories

Brenda Laurel asks ‘What if children were the agents of their own empowerment?’ (2000, p. 244). In *Sounding Stories*,⁵⁰ we have explored this idea, creating a work in collaboration with children. *Sounding Stories* was developed in collaboration with children from the Burmese refugee community in Ringwood, Victoria. This work was similar to *In Touch* in that it was presented in the Art Space gallery in Ringwood. A series of workshops were conducted to generate visuals and audio from children (aged approximately 5 – 12 years). The audio that was activated by participants’ touch was predominately recordings from the children augmented with music and sound effects by composer Cayn Borthwick. The children also designed the illustrations that were re-created by illustrator Edwina Atkins on the gallery walls. The paintings could be activated by touching conductive paint. *Sounding Stories*’ aim was to engage with the community in a fun and innovative way by bringing children’s imagination to life through the exploration of character, narrative, sound and colour.

Bruner (2003) discusses the importance of narrative in developing children’s identity and imagination. We were also interested in exploring Hall & Bannon’s notion of ‘narrativity (storytelling and narrative creation play a pivotal role in children’s education environment)’ (2005).

The modes of interaction outlined in this research project were considered during the development of *Sounding Stories*. As the contact points were quite a distance from each other solo play was observed more than collaborative play.

One of the main issues with *The Plants* was the small scale of the work. *Sounding Stories* took place in a large gallery, therefore, there was much more space for participants to play in.

Sounding Stories addressed the Observer to Participant journey:

Create the installation in an area that can be easily seen by people passing by.

⁵⁰ <http://www.playablestreets.com/sounding-stories/>

The public gallery *Art Space* is connected to the Ringwood library and has large doors which allow the public to see the majority of the installation as they walk by.

Create a space that appeals to people of all ages as family and friends will invite others to the work.

As the imagery and sounds were predominately created by children the work seemed to have an inherent appeal to children. This aesthetic may have been a detractor for some older participants but we did observe a varied age range participating.

Develop a sense of 'magic' and 'wonder', this will facilitate 'curiosity'.

The larger than life drawings and lighting added to the wondrous environment of the installation. Many observers were drawn in to participate because of the bright and large-scale nature of the work.

Decide on a performative task for the facilitator that will invite an observer to become a participant.

As this was a month-long installation we were unable to be in the gallery full time. We did spend some time in the gallery talking to participants and encouraging participation but no set performance tasks were made.

This installation demonstrated adherence to the solo play design criteria from this research project:

Encourage musical games by adding layers of complexity in sound and technology.

This installation added complexity by offering participants 10 points of contact (conductive paint) to trigger sounds. Each point of contact would trigger 10 – 20 unique phrases, sound effects or musical motifs. This meant that as participants walked around the space triggering sounds they would experience a different 'narrative' each time.

Create an installation big enough that a solo performer can explore the installation alone.

The size of this installation allowed much more solo play than *The Plants*. Participants could move around the space and trigger sounds that came from speakers directly above them, creating an isolated solo experience.

Create an environment that has enough space for games to develop in.

Through workshops with primary school students, we developed a series of games. One consisted of the students sitting in a circle drawing, one at a time a student would stand up and activate a sound anywhere in the space. This sound would be incorporated into the other student's drawings until they had created a whole story from random snippets of audio.

This work also demonstrated the interactive touch-based musical installation design criteria for collaborative play:

Create accessibility barriers to some participants' interaction (i.e. 1 – 4-year-olds) to encourage collaboration with parent/ guardian.

The contact points for activating sounds was approximately two metres off the ground. This allowed most participants to interact with the work, children younger than approximately four years were often lifted by their parents (or brothers/ sisters) to trigger sounds.

Some technology on display (wires or buttons etc.) will encourage the 'teacher – student' collaboration.

Although the technology in *Sounding Stories* wasn't on display (the *Raspberry Pi* units were hidden behind the speaker boxes) we witnessed the teacher-student collaboration. Young participants especially would instruct others where they could touch the walls to make sounds.

Create an installation with sensors that are close together to facilitate ‘unintended collaboration’.

The phenomenon of ‘unintended collaboration’ was observed as participants would often interact with the work at the same time, all adding to the overall soundtrack of the space.

The design criteria for ‘all modes’ of engagement were also utilised:

Consider the accessibility of the space to encourage interaction by all age groups and ability levels.

The ‘contact points’ that triggered sounds were deliberately set low to encourage interaction from younger audiences. It also allowed participants in wheelchairs to access all of the touch points.

Make sure the technology delivers a consistent result to encourage exploration, interaction, collaboration and play. The user should feel like she/he is responsible for creating the sound of the installation with their touch.

The contact points within the installation were very responsive. We had a few problems with some of the contact points but these were fixed by running copper tape across the conductive paint (a fix developed during the *In Touch* installation).

Sonic aesthetics (i.e. sounds chosen) will be up to the artist but consider the effect they will have on the participant.

As this was a cut-up story participants could choose their own path through the narrative. They would never get the same story twice but they could choose where to activate the sounds within the space.



Figure 50 - Sounding Stories installation at ArtSpace REALM Ringwood 2017

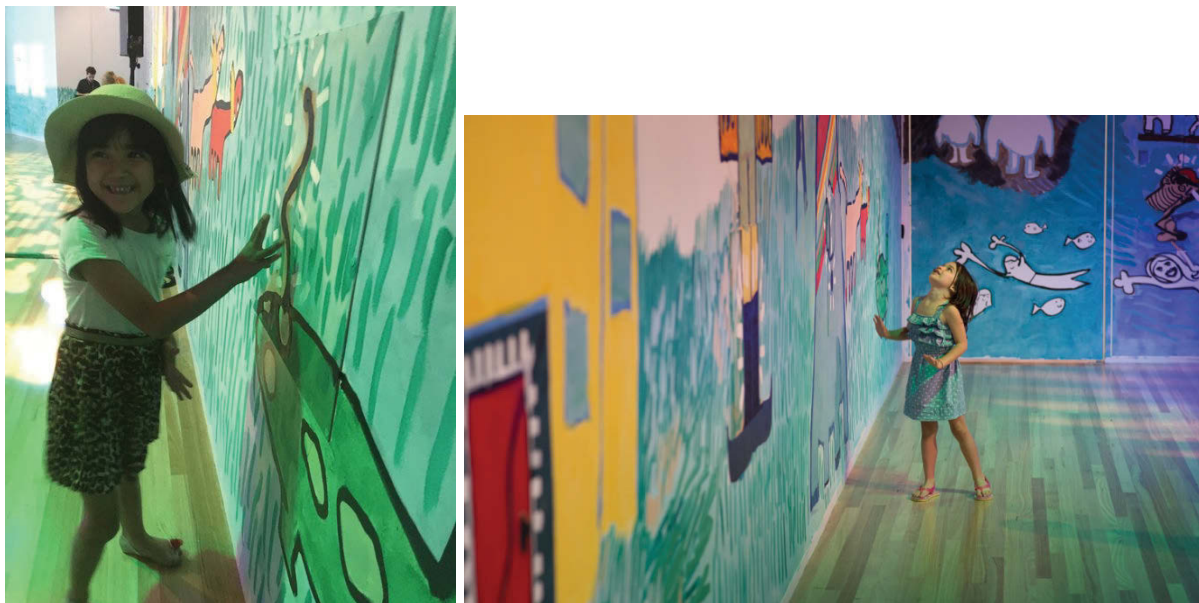


Figure 51 - Connecting to the conductive paint to trigger sounds.

8.4 Clippy

*Clippy*⁵¹ is a stand-alone unit that looks a bit like a salad bowl, with two buttons, one to select sounds and one to 'reset' the clips. 12 magnets around the edge connect to oversized clips on wires. These clips can be connected to anything conductive (i.e. fruit, foil, water, playdough, etc.) to create triggers for sound. These triggers can be used to create musical compositions. Students of any musical skill level can create tonal music compositions and play them using this unique interface. *Clippy* is an instrument that is always in development, *Clippy* Version 1.0 was thoroughly tested by the students of Lismore (VIC) Primary School as part of the inaugural 'Virtual Creative Professionals in Schools' program. Students worked with *Clippy* for 2 weeks, making music, writing stories and drawing improvements. A *Clippy* unit now resides at the school to continue their sound investigations and musical compositions.

Clippy does not specifically address the observer to participant journey as it is utilized within a structured workshop environment. Some design criteria were addressed as they were also appropriate for this primary school workshop setting.

Develop a sense of 'magic' and 'wonder', this will facilitate 'curiosity'.

The *Clippy* device was demonstrated to the students first with copper tape stuck to a table, this turned their once familiar classroom table into a musical instrument. Students were then asked to bring in something from home that could be turned into a 'trigger'. We had an interesting array of objects from a cup of water with rocks in it to a wet shoe, all of which we used to make music.

⁵¹ <http://www.playablestreets.com/clippy-v10-lismore-primary-school/>

Clippy demonstrated some of the solo play design criteria developed from *The Plants*:

Encourage musical games by adding layers of complexity in sound and technology.

Clippy had three banks of sounds that included piano, guitar and marimba (all with notes from the C major pentatonic scale). Some clips also controlled sound effects such as horses, chickens, cheering and laughing. One of the games that these sound effects inspired was a spontaneous puppet show in which half of the students grabbed soft toys and began to animate them as other students triggered sound effects and narrated the story.

This work also demonstrated the interactive touch-based musical installation design criteria for collaborative play:

Decide on a performative task for the facilitator that will encourage Musical Collaboration.

We developed performative tasks to keep students engaged in the workshop. This included playing acoustic instruments whilst students accompanied on triggers they had made connected to the *Clippy* device.

Create an installation with sensors that are close together to facilitate 'unintended collaboration'.

As *Clippy* is a small device and the wires connected to the device are a maximum of 1.5 metres long students were forced to collaborate. Even though they sometimes didn't recognize that they were contributing to the overall sound output. This sometimes led to a cacophonous sound as every sound triggered at once, it also led to unintended collaboration and musical collaboration.

The design criteria for 'all modes' of engagement were also utilised:

Consider the accessibility of the space to encourage interaction by all age groups and ability levels.

Clippy is a portable device that can be hooked up to many different objects, this means that it was accessible to all students in the class.

Make sure the technology delivers a consistent result to encourage exploration, interaction, collaboration and play. The user should feel like she/he is responsible for creating the sound of the installation with their touch.

This was an important factor in the design phase of *Clippy*, we made sure that contact points were very responsive with as little latency as possible. This did become an issue when some unreliable triggers (such as the wet shoe mentioned earlier) were used.

Sonic aesthetics (i.e. sounds chosen) will be up to the artist but consider the effect they will have on the participant.

The mix of musical notes and sound effects were effective to develop variety within the workshops. The sound effects, however, were problematic as they dominated the sonic space. Future iterations would benefit from having any sound effects on a different bank from the instrument sounds.

The sounds that the installation produces should be complex enough to create a pleasing sound and be 'playable'. The sound should not be so complex as to disrupt play or hinder non-musicians.

Based on the results of *The Plants* study we decided to use a C Major pentatonic scale for *Clippy*. This worked well as students could create chords and melodies rather easily. More testing on both musicians and non-musicians will be required in future developments of *Clippy*.



Figure 52 - Clippy V1.0 prototype.

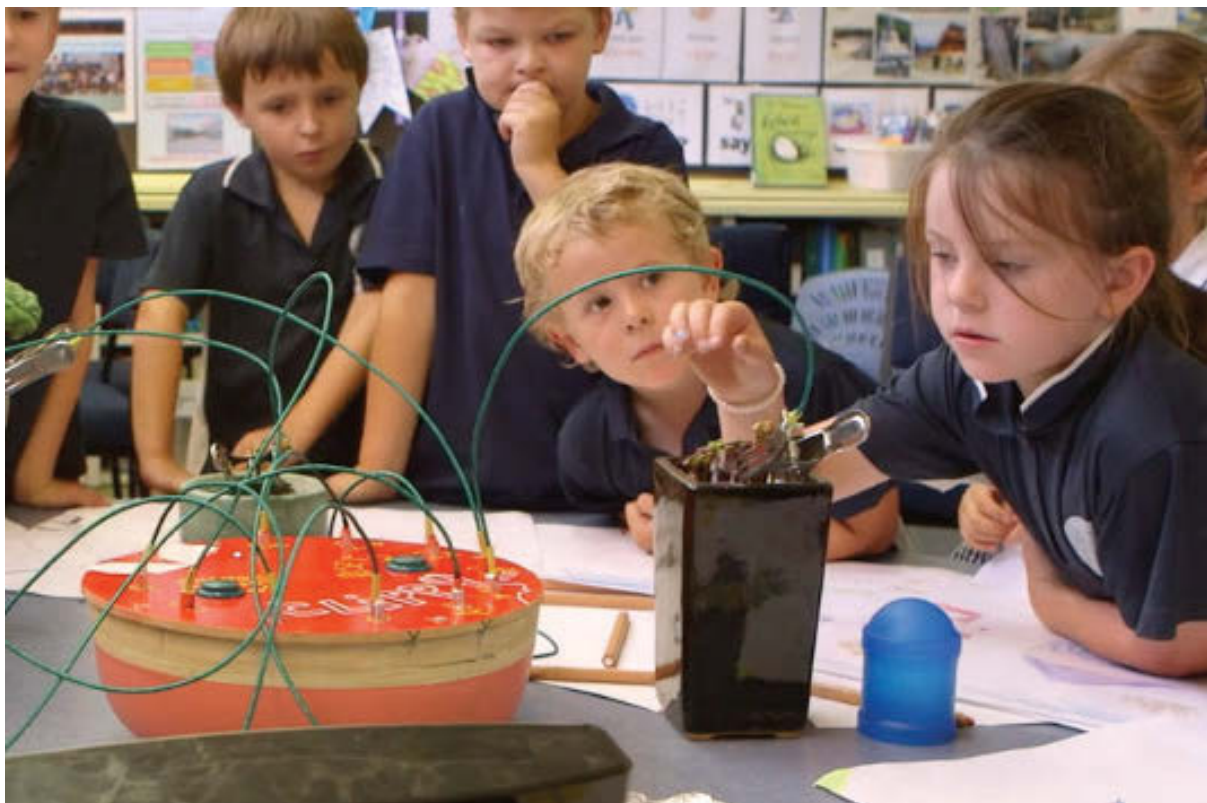


Figure 53 - Clippy V1.0 being used in a primary school workshop.

8.5 Future research: Cooperative Inquiry

My future research will focus on a participatory design process, developing work with participants in a workshop environment. Through my work with *Polyglot Theatre* I have found that developing work with children makes for dynamic artworks. Children should find themselves as creators of technology and active participants in the design process, rather than mere consumers or spectators ([Trappe 2012](#)).

'Cooperative inquiry' ([Rust et al. 2014, p. 305](#)) or participatory design ([Horton et al. 2012](#)) could be a useful tool for developing new interactive works with children as co-designers.

Allison Druin breaks down the 4 methods used when designing with children: 'Child as... User, Tester, Informant and Design Partner' ([2002, p. 4](#)). Child as 'Design partner' means that children are significantly involved in the entirety of the design process, 'Children can grow to see themselves as something more than users of technology. They can come to believe that they can make a difference.' ([2002, p. 27](#)). Through a combination of observation, low-tech prototyping, and time-intensive technology use with children Druin gathers data and designs interfaces constantly being informed by her children co-designers. Examples of children being involved later in the design process (Child as User, Tester and Informant) can also be used to great effect ([Xu, Mazzone & MacFarlane 2005](#)). This is especially relevant in the development of the *Clippy* device discussed in this chapter.

Often it seems that working with children within the design process results in outcomes that are more relatable to children and more novel for older participants. As shown in the *Sounding Stories* development and installation children create ideas and concepts that are often surprising, surreal and unique.

8.6 Conclusion

In this chapter, I have discussed the interaction modes and design criteria outlined in chapter seven in relation to recent works by *Playable Streets*. I have discussed 'skin to skin' musical installation *Reach Out Sounds*, collaboratively designed interactive installation *Sounding Stories* and interactive musical device *Clippy*. Each work demonstrates that the design criteria developed here can be used to enhance a variety of interactive touch-based musical installations and interfaces. It also shows that designers can be selective in the design criteria they use to create specific works.

I have also outlined future research to be undertaken regarding cooperative inquiry and the focus on designing new interfaces and installations with children as design partners.

9. Conclusion

Chapter one outlined the structure of this research project and briefly discussed the background of my arts practice. I broke the term 'interactive touch-based musical installation' into sections to explain the nature of the works created for this research. I described the significance of the research and outlined the two main questions that were the basis of this research project:

- How do people interact with the installations?
- What are the design criteria that will help improve the engagement, interaction and collaboration in future iterations of these works?

In chapter two I discussed frameworks and design criteria that have influenced the design of *In Touch* and *The Plants*: 'The Creative Engagement Model' ([Bilda, Edmonds & Candy 2008](#)), 'The Pleasure Framework' ([Costello & Edmonds 2007](#)) and 'Hall and Bannon's Working Framework' ([2005](#)). I also explored touch-based interfaces, musical interfaces, and interactive installations. I discussed creative works to illustrate the current state of the art. I found that the balance of complexity and simplicity within music interaction design is a common challenge for designers.

Foundation work (chapter three) gave an insight into my early experiments and collaborations which led up to the installations that are discussed in this research project. I also outlined the main findings from nearly five years of performance, collaboration and research.

In the methodology chapter (chapter four) I discussed constructionist grounded theory in relation to the research methods that I have chosen to use. I illustrated the cyclical nature of my research structure as data is gathered, theory is developed, implemented, then redeveloped from new observations. The research methods of participant surveys, video analysis, collaborator interview, field notes and recordings were discussed.

Chapter five discussed in detail the two interactive touch-based musical installations created for this research project: *In Touch* and *The Plants*. *In Touch* was used as a

pilot study, results of a participant survey were outlined and an initial design criteria was proposed. The technology, sound and design of *The Plants* installation at the Abbotsford Convent was also examined. The installation was then discussed in relation to the preliminary design criteria.

The observations chapter (chapter six) explored the data that was gathered for *The Plants* installation. This included an interview with collaborator and composer Cayn Borthwick, 4 hours of video documentation as well as my field notes and audio recordings. The key findings of this data were discussed and clear themes began to appear such as the observer to participant journey, interaction modes of solo and collaborative play and a series of design considerations.

In chapter seven a design framework for the development of interactive touch-based musical installations was proposed. This included an engagement model that demonstrated the observer to participant journey, solo play and collaborative play. I then outlined a set of design criteria related to this engagement model to aid future iterations of the works discussed in this research project as well as new works.

The design criteria proposed in chapter seven was discussed further in chapter eight in relation to two installations and one interactive instrument created for school workshops. I also outlined future research which will focus on developing new works with children as design partners.

This research project has presented the evolution of design criteria for creating interactive touch-based musical installations. I have illustrated a 'journey' from an observer to participant by observing public engagement within these installations. I hope that these design criteria will help to inform the creation of more artistic experiences that encourage the public to step across that invisible line between observer and participant.

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Appendix A – Links to Video Footage & Images

The Plants

<http://www.playablestreets.com/the-plants/>

In Touch

<http://www.playablestreets.com/in-touch-art-space-1/>

Reach Out Sounds

<http://www.playablestreets.com/reach-out-sounds/>

Sounding Stories

<http://www.playablestreets.com/sounding-stories/>

Clippy V1.0

<http://www.playablestreets.com/clippy-v10-lismore-primary-school/>

Appendix B – Publications

Walton, G. 2016, 'In Touch: An Interactive Exhibition' paper presented to the *Proceedings of the 28th Australian Conference on Computer-Human Interaction*, ACM.

Appendix C – Field notes

- It was evident that more time was needed in the development phase. Cayn and I had three days to develop the work from initial concept to presentation. This included building the installation, all the programming, and developing the sounds. If we had more time we would have done extensive tests with the public before presentation and developed the sounds through this process.
- A more efficient way of moving the planter boxes and plugging them in is needed in the future. This part of the design process would also benefit from more development time and testing in the final installation area. One idea we had for developing the design included having sections that could be moved separately and easily joined together using a 'connection panel' on each section.
- It needs to be bigger so that families can play it together. This is discussed more in 6.4.3. I noticed within the first few hours of presentation that the installation could benefit from scaling up. Ideally, it would be big enough to accommodate 20 – 30 people interacting at the same time. This would mean creating six or seven more sets of plants, allowing groups to occupy areas of the installation or solo players to explore on their own.
- There was a notable moment of interaction with a girl in a wheelchair with cerebral palsy. She could play the plants without much assistance and I could see that she was enjoying the experience. This illustrated the importance of accessibility within the work. As these installations are open to the public access for all ability levels should be a big consideration in developing future works.
- Although the installation could be accessed from both sides, it was mostly accessed from one side. This was probably because the participants walked up to the installation from one side only. Changing the layout of the installation (i.e. to a 'U' shape or a triangle) may encourage participants to move around the installation more.
- The idea of chaos is a fun one to toy with, it can be loud and crazy but that is sometimes good. The musical scale, based on the harmonic series used by composer, Cayn Borthwick allowed for very erratic playing to sound musical,

energetic and mysterious. This was pleasing to the ear but as noted in 6.4.3 this led to issues with the 'playability' of the installation.

- Not many people deliberately played the installation together. It would be worth exploring ways of encouraging more collaborative interaction. This may involve developing more demonstrations of the capabilities of the installation by the facilitators (Cayn and myself). We may also encourage interaction by scaling up the installation so participants have more space and sound options to create music together.
- The technology used could be improved to allow for more nuanced expression from a participant's touch. The research done by Poupyrev et al. ([2012](#); [2012](#)) and Müller ([2011](#); [2012](#)) show the possibilities of capacitive touch to affect more than a simple binary function. It may be possible with this technology to control reverb, modulation or sustain of the instrument samples used.

I made audio recordings of portions of the work and noticed a few things that I missed from the video documentation.

- I found the scale (based on the harmonic series) that Cayn has chosen was very effective. It sustained interest regardless of what tempo the plants were played. The varying tempo of the piano reminded me of the minimalist compositions of Karlheinz Stockhausen such as Klavierstück V.
- I found it great to talk to the adults about how the installation was developed and how it works. This curiosity kept people around the installation for a long time. Often parents would talk to me or Cayn about the technology behind the installation while they would play the plants.
- The piano setting was by far used the most, often when the setting was changed to synthesizer or bird sounds people would ask for it to be switched back to piano. This demonstrated the need for a larger installation. I think we could have more instrument options such as bass, strings, woodwinds etc. but they would have to be on a different set of plants. Having the same sound (i.e. the piano) meant that people could get used to it and begin to play it more like an instrument.

- I especially liked having long conversations with the children as they figured out how the installation worked. Like the adults, the children's curiosity would keep them engaged in the work longer and they would often interact with the installation as they were speculating on how it functioned.