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A cubic approach as a tangible interactive device to measure improvement in children's well-being in hospitals

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[1]**Disclaimer:** This report is submitted as part requirement for the MEng Computer Science at UCL. It is substantially the result of my own work except where explicitly indicated in the text. The report may be freely copied and distributed provided the source is explicitly acknowledged

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Abstract

Many children hospitals have adopted *play* departments to help children and young people deal with any fears or worries about hospitals, illnesses and treatments. Hospitalisation can be the first challenge that children encounter, and it is often difficult to understand their feelings as they tend to hide their emotions. This research suggests a cubic approach to create a novel and playful tangible probe that assists children, their families and experts about their wellbeing. This research has used semi-structured interviews, focus groups and workshops to explore 1) the relationship between interpreting children's emotions through observing their interactions 2) how to utilise play methodologies and supplement environments that can make the recovery process fast and 3) designing tangible interfaces that promote social interaction, reflection and collaboration. The design of the cube has shown promising findings that it is effective in mapping emotions to different interactions for both children and specialists. The workshop with the play specialist team at GOSH further proved the practical applications of the cube in pre-op assessment, pre and post surgery as well as regulating a child's emotions.

Contents

Chapter 1

Introduction

Disease and hospitalisation can be the first real crisis a child encounters. It can be an overwhelming incident and the experience of hospitalisation can be viewed as a whole of regaining of the individual's status in the world [1]. Often it is very difficult to understand and empathise with hospitalised children as children tend to hide their emotions and how they are truly feeling in an alienated environment.

Child hospitalisation is a stressful event for both the child and their parents [2]. Measuring a child's physiological parameters is often not a pleasant event and in most cases, people try to avoid having such experiences. Especially, for young children routine measurements can be very daunting and unsettling as many situations and devices can appear threatening.

The Great Ormond Street Hospital (GOSH), since its formation in 1852, has dedicated its efforts to children's healthcare and to finding innovative ways to treat childhood illnesses. GOSH is also the largest paediatric centre in the UK that receives over 252,389 outpatient visits and 43,778 inpatient visits every year [3]. GOSH possess 63 different clinical specialities, the UK's widest range of specialist health services for children. To provide a better experience for treating childhood illnesses, GOSH put forward different teams of *play* specialists that help children in different ways. The play specialist helps children prepare for life-saving treatments, bringing fun into the hospitals, supporting the whole family as well as speeding up recovery [4].

Furthermore, the experience of children in their interactions with other children, doctors and nursing professionals while in hospital is a critical subject matter. It has been shown that children positively value the interactions and communications that occur between them and the nursing professionals, which included social and emotional factors [5]. It has also been concluded that communication established with children is a critical pathway in understanding their experiences while in hospital.

Children's well being can be improved through high-quality experiences and social interactions. In today's digital world, the relationship between digital technologies and social interactions have highlighted that modern technologies (especially within households) are leading to increasing privatisation within individuals, as well as negatively impacting their social interactions [6]. It is therefore essential to explore designing alternative *tools*, using non-screen based outputs that can assess how children can interact with technology that can be indirectly be used to monitor their improvement.

Young children deal with many of the same emotions that adults deal with, however, they often do not have the words or the right actions to communicate about how they are feeling. Often such miscommunication can be regarded as inappropriate behaviours or in very physical manners [7]. Different strategies can be adopted to help children understand and express their emotions. The following strategies are some ways that has been considered in the design of the cube in this research.

One of the most effective ways to help children express their emotions is to give them lots of opportunities to identify feelings in themselves and others [7]. This could be achieved through an engaging activity where a child could reflect on how they felt and also whether what someone else may be feeling. Additionally, children can be taught in different ways how they can respond to specific feelings and problems they are facing. It is crucial to understand how mixed feelings can be expressed through various methods; hence, it's key to build trust and effective communication with children.

This research has investigated how a new technology probe can be used to design a new kind of device that will be used to improve health monitoring systems for children. Additionally, to change unsettling experiences, this research explores how to design a playful and joyful experience for the children.

In the remaining chapters, a playful cubic design is proposed that measures both *physical* and *mental* aspects of a child. The second aim of the cube is to act as a communication device (conversation starter/icebreaker) between the children and medical staff, other children in the hospital and even their own family. Such a communication device could reduce anxiety and fear of check-ups within the hospital and perhaps create more productive interactions between the children and the medical staff. Also, monitoring a child's well-being regularly can help in detection of early illnesses. The design and the practicality of the cube was evaluated through a qualitative approach using multiple semi-structured interviews, focus groups and workshops in collaboration with GOSH and the Young Persons Advisory Group.

Chapter 2

Literature Review

This section provides an overview of the most relevant previous work, there are four key sub-areas are explored as follows: 1) properties of tangible interfaces that make them unique, 2) principles of playful interaction, 3) studies of people interacting with tangibles, especially children and 4) novel research done on asking people how they feel using specially designed questionnaires and applications.

2.1 Properties of Tangible Interfaces - Cubic Design

In this section, properties of tangible interfaces of cubes are explored. Highlighted topics include cube affordance, i.e. what are the best design methodologies to consider when designing a cube for interaction as well as, how cubes are used to measure physiological and mental parameters through different design interactions and concepts.

2.1.1 Affordance

Creating and choosing the best design choices to create physical interfaces requires substantial detail to a set of characteristics. Sheridan et al. (2003) explore cube affordance, using physical interfaces as alternative methods to traditional input methods [8]. Often it is difficult to learn and use wearable input technologies and interfaces. Therefore, being able to design effective physical interfaces could create more enhanced usability and experiences.

To develop a desirable physical interface, one should understand how users build an intimate relationship with an object or how they disassociate themselves from controlling an object. It is vital to gather as much information as possible about users and their interactions. Although gesture has played a vital role in defining physical interfaces, Sheridan et al. (2003) focus on using hands and how users physically manipulate objects.

To answer some of the critical questions over cube affords and how users naturally interact with a cube, a design study was proposed that highlighted a set of unique characteristics that a cube holds. The features are different size cubes, the texture of the cube, colour and patterns, different weight of cubes, exploration of the shape and sound. Users will always be physically dissimilar from each other and would have a unique set of preferences. However, Sheridan et al. (2003) present specific attributes that would be desirable to all physical interfaces.

They conclude that participants preferred form over function. This meant that participants interacted more with cubes that looked different/unusual in comparison to the conventional design. The cubes that provided feedback (e.g. through sound or squeezing) to the participant prolonged their interaction. If the cube provided a multi-sensory experience (two or more), this also extended the interaction and was favoured over others. Multisensory is a blend of texture, visual, colour, smell, sound, size, form and weight. Finally, it was concluded that some degree of weight is desirable as well as the size of the cube is relative to the application and the user of the interface.

2.1.2 Tangible interaction

Building on top of Sheridan et al. (2003) work, Hornecker and Burr (2006) focus on "tangible interactions", highlighting embodied interactions, tangible manipulations as well as physical representations of data [9]. As computing is moving beyond the desktop, and increasingly more involved in embedded physical environments, it is important to understand the design principles for such new interfaces. Hornecker and Burr (2006) introduce a framework that aims towards user experience, which reveals the interweaving connection of physical and social aspects of interaction.

The framework proposed is structured around four themes, offering different outlooks on tangible interactions. The key themes are:

- **Tangible manipulations** focus on the different material representations i.e. different tactile qualities that can be manipulated
- **Spatial interactions** explore movement in space and tangible interactions are rooted in real space
- **Embodied facilitation** refers to how the environment and setting of material objects can affect group behaviour
- **Expressive representation** highlights the legibility, expressiveness of an interaction system and focuses on the material and digital representations.

The framework provides a unique perspective that enables us to understand and come to grips with social aspects as well as user experience of tangible interactions.

2.1.3 Accessibility & Engagement

To further explore the implications through some of the social aspects as well as user experience of physical toolkits from Hornecker and Burr (2006) work, Lechelt et al.(2018) investigate a cubic approach in creating physical toolkits that encourage collaboration, sustained engagement for effective learning in general and specifically in special needs schools [10]. This is due to the increase of demand for teaching of computing in school curricula, the need to make computing more accessible to a diver range of learners. The introduction of this physical toolkit investigates how it can be helpful and supportive in learning about computing for special education needs (SEN).

Lechelt et al.(2018) findings consisted of the interaction with the interface of their toolkit as well as the interaction between participant during the learning tasks. The research showed that a physical toolkit for teaching computing can be very effective for SEN classrooms. As well as helping comprehension for learning technical matters, the toolkit created excitement for learning and gave rise to collaboration and engaging experiences. Especially in SEN schools as the students often have a broader mix of abilities and needs in comparison to mainstream schools.

2.1.4 Design for Health Monitoring

The concepts and methodologies explored in previous literature can be applied in health especially targeting children. Since, measuring physiological aspects of young children to assess their well-being can be a stressful situation, whether it is conducted at a hospital or at home by their parents. Vonach et al. (2016) present a concept that can reduce anxiety and stress that examination and test setups can cause to young children [11]. They explore cube shaped tangible objects which are fitted with noninvasive sensors which young children can interact with measuring pulse, temperature blood oxygen saturation and lung capacity.

Vonach et al. (2016) design of a health monitoring cube consisted of a storytelling game, guiding children through unobserved physiological measurements as an enjoyable experience. This approach can help to make monitoring of a child's health much more enjoyable which can result in the recognition of early symptoms and saving lives. Moreover, Grönvall et al. state that people reject surveillance technologies for home monitoring health systems [12]. Hence, if passive physiological sensors are embedded through a tangible object, it would be a more practical approach.

Vonach et al. (2016) research concluded in presenting a viable concept of creating a home health monitoring cube for children. The feedback of their user study showed very high acceptability. Additionally, the home health monitoring toy proved to be feasible that could be pursued further to extend its features and functionality.

2.2 Principles of Tangible Interactions

Media and new technological spaces can create a space of support of collaboration between a variety of groups and environments. For instance, Dourish et al. (1992) investigated how such spaces can support access to information that supports awareness [13]. Awareness is an example of what activities are happening and knowing who's around. Hence, this may lead to different types of interactions, spontaneous connections and development of shared cultures.

2.2.1 Playful, Lightweight and Engaging Interactions

Many organisations stride for redesigning of their workplace as well as considering it a fun place to be. Since they believe this will result to better economic and social benefits. Gallacher et al. (2015) explore a lightweight approach designed as a "Mood Squeezer" that asks people to reflect their mood by squeezing a coloured ball [14]. Squeezing the balls mirrored an aggregation of the colours pressed, onto a colourful public floor display.

This research resulted in people deviating from their routines to interact, watch and talk to others about the visualisation's that were created on the floor. The technology intervention was viewed positively after the study was conducted. Additionally, some of the key themes that emerged after the study are presented below:

- **Playfulness -** The mood squeezers were seen as playful and fun to interact with as well as being textually and visually appealing.
- **Reflection -** For some of the participants, squeezing the balls became a more personal activity, where they began to think more deeply about their mood and how they were feeling
- **Social norms -** Some interviews showcased how some participant felt anxious or frustrated when others did not participate "the rules" or if others pressed the balls in random successions. The open-endedness of the study created assumptions a general mapping to emerge that majority of the participants would use.
- **Conversations and ice-breakers -** The fact that there was no apparent correlation between a colour and a mood, this often acted as a point of a conversational ice-breaker, especially during mundane situations, such as waiting at a coffee machine or the elevator.

Gallacher et al. (2015) conclude that a theme of "play" within a workplace, using tangible playful technology can bring a positive impact towards individuals, groups and organisations. Another approach worth exploring is interactions with large public displays, as they are increasingly being placed in public places for either social activities or to support communities. Brignull and Rogers (2003), explore this new form of public interaction and the resistance of public in participating [15].

To overcome feelings such as embarrassment they propose a system called the "Opinionizer", designed social gatherings, encourage socialisation and interaction. The conclusion of the study showcased that for public interactions to become popular, it requires a clear purpose, with clear guidance and no ambiguity.

2.2.2 Advantages of Playful Interactions

Both Gallacher et al. (2015) and Brignull and Rogers (2003) explore the theme of playfulness. Playful interaction involves an attitude of freedom, joy, possibilities and imagination. The studies above showcase how during play the focus isn't necessarily to distract ourselves with the reality, instead it is a personal way of interpreting and uniquely finding meanings. Since it should be about the freedom that gives the opportunity to explore different options by being free from the consequence of mistakes and the fear of being wrong. Additionally, Rob Tieben (2015) infers that by activating play and stimulating teenagers can lead to an increase of social interaction, creativity and Independence [16].

The advantages and consequences of playful interactions often encourage reflection and sustained use. If an interaction elicits delight as well as sustaining the user's interest and play for a more extended period, the user is more probable to have a stronger emotional attachment and interest. Therefore, designing interfaces to be playful can encourage and support opportunities between users (i.e. between children, teachers, families, the natural world around us) and such connections are the building blocks that strengthen relationships and creativity. Finally, play is learning as Bruno Bettelheim states:

> "*Through play more than any other activity, children achieve mastery of the external world*"

2.2.3 Parent-Child Collaboration

To go beyond some of the studies done by Gallacher et al. (2015) around the studies of people interacting with tangibles, Zuckerman et al. (2018) discusses tangible interaction that involves explicitly children. The design of a simple and tangible "Awareness Object" (AO) planned to raise awareness and reflection between the parent and the child during an activity.

By creating a collaborative activity, the parent-child interaction could result in parents envisioning their child's mental state and behaviour. By using AO Zuckerman et al. (2018) created a focus for parents to pay more attention when interacting with their children, which led to various types of reflection by both parents and children [17]. They also conclude that tangible attributes can increase involvement and interaction. However, when evaluating the interaction, this could be a sensitive area as not all parents were able to successfully cope with join reflection with their child, due to different parental believe systems.

2.3 Innovative Information Gathering

Traditional gathering methods of opinions such as surveys at events are typically boring since they do not add any immediate value to the respondent or perhaps it disrupts the positive experience. Hence, this usually results in deficient quality and response rates. Golsteijn et al. (2015) propose an alternative solution, with the design and implementation of "VoxBox" [18].

VoxBox is a playful and engaging tangible system that gathers opinions from public events. To prevent disrupting the positive experience of participants, the system was designed in a way that would engage and invite people to use it without any other intervention. Additionally, it used multiple different mechanisms and modules to gather opinions. Each module served a different purpose. However, the mechanisms used were familiar to the people that were using them. The different mechanism used included a range from buttons, sliders, knobs, spinners and even a telephone, where a user would hear a question and then would be able to answer it via the phone. Besides, the system included a tube which dropped a ball as each step was completed, creating an incentive for the participant to complete the exercise.

Voxbox managed to open up conversations around systems around the sharing of opinions through engaging users through playful and exciting interactions. Creating playful activities using a life size tangible machine, showed great promise at inviting people to share their views in comparison to the traditional questionnaire approach.

2.3.1 Fun Toolkit and Other Survey Methods

As observed from the previous paper, it has been shown how ineffective traditional survey methods are in gathering opinions. Therefore, such processes will be even more inefficient when used to collect opinions from children. Children's views are beneficial as they contribute ideas to different designs. This then helps to understand the mental models of children and even use their information to improve and create interfaces.

Read and MacFarlane (2006) explore survey methods within Child Computer Interaction (CCI), and the result gathered suggest that using a physical interactive product to collect information from children is based on how fun the product is perceived to be [19]. Hence, if the product is playful and fun, the results will be easier to be collected and also more effective. Furthermore, they state that success in a survey in CCI does not necessarily have to correlate with stability or reliability of the reports, instead such studies enable us to get a glimpse at their dreams, ideals and their worlds.

Some useful guidelines and approaches that can be taken into when designing tools to make surveying process more valuable are presented below:

- **Keeping it short -** Whatever activity children have to complete, it is essential to mind their time and fit their time span. This will prevent children from losing motivation rapidly when answering questions.
- **Piloting the language -** It is vital that children can read the question or instruction; hence, any words or material should make sense and not difficult to interpret.
- **Make it fun -** If the process can be made fun, this improves the experience and engagement
- **Not taken it too seriously -** It is important that the researcher does not read too much into data during the research and development stage. It is possible to understand trends and outliers from responses than applying precise statistical tests.

2.3.2 Inconvenience of Health Measurements

There are promising developments in tackling health disparities across different societies. However, there are critical challenges in finding appropriate and sufficient health measurements across different organisations and health groups. Four challenges proposed by Burgard and Chen (2014) which consider the degree of inequality, effectively targeting resource and in general reducing disparities[20]:

- Comparisons may be challenged by different distributions of disease
- Comparisons may be challenged by the differences in quality and availability of data used to measure health

- Comparability of diagnosis bias and avoidance based on self-reported health information due to different social groups and societies
- If questions and concepts are interpreted differently, self-reported overall health measures might not be comparable across groups.

Alongside these overall challenges, there are other particular challenges required in measuring health and well-being within children. Hence, it is imperative when designing a technological probe to keep in mind such problems and to try and minimise them as much as possible.

Monitoring patients' pain is a critical space for clinicians, although, regular based pain measurements from patients can often be troublesome and time-consuming for the clinicians. Additionally, recording pain usually results in longer hospital stays. Further problems include inaccurate pain measurements as patients can feel inhibited about expressing their pain in certain situations and environments.

Price et al. (2018) present Painpad, a tangible device that enables patients to self-record their pain. Another advantage of self-logging is that it enables the patients to develop a better understanding of their overall condition and allowing them to be actively contributing to their care [21].

The key contributions of this approach include an easy to use and robust tangible device for self logging of pain. Rates of compliance, frequency and accuracy of pain scoring from the patient were improved. Additionally, insights into the preferences and needs of patients were identified. Furthermore, by enabling patients to record their pain the need for clinicians to engage in troublesome data collection, processing and management were reduced.

2.3.3 Children's Role to their Well-being

Involvement of patients to measure and to record their well-being has been shown to be valuable as shown in Price's study. Moreover, this idea can be developed towards the role of children in measure and monitoring their own well-being. Ben-Arieh (2004) focuses on different roles for children involvement towards their well being [22]. Moving away from traditional methods to look at children's well being, Ben-Arieh et al. (2001)proposes six questions that focus when studying towards children's well being [23]:

1. What are children doing?
2. What do children need?
3. What do children have?
4. What do children think and feel?
5. Who are children connected to?
6. What do children contribute?

To understand children better and answer the following it is essential to focus on children's daily lives and routine. Studies by Funk et al. (1999) and Gottlieb and Bronstein, (1996) have shown that parent does not know what their children are worried about and how they are spending their time [24][25]. Therefore, Ben-Arieh suggests that we should involve children directly in studies and research done towards them.

To be able to create meaningful studies and design procedures it is essential for children to be part of the design studies and to be the sources of information. This should be relevant to all children from different backgrounds and groups. Since children know what is "important" in their lives as we can evaluate their quality of life by asking them directly. Furthermore, children can help towards data collection and analysis as their direct involvement can open up ended research goals that might not have been considered before.

Ben-Arieh concludes that children often have impressive and relevant abilities to express their views and experiences. Children also wanted to be asked and involved in research that matter and often believe they are capable of contributing to the research area, which shows their willingness to take an active role in their well-being. Finally, by creating the right environments as well as enabling children to play an active role during the research process, about areas they care about, we would be able to learn a great deal from them as well as design effective tools for them.

2.4 Aim

The aim of this study was to create a novel and playful tangible technological probe that can aid in exploring children's well-being in hospitals. The objective was to examine how children communicate their emotions as well as their well-being and how tangible devices can be of help to understand this. These include exploring the most effective properties of tangible interfaces, playful interactions that encourage reflection and sustained use and how interacting with tangibles especially for children can help in a medical setting. This research centres around the three main research questions:

1. How can we understand and interpret the emotions and feelings of children in regards to their well-being through interactions?

2. How do we design indirect play methodologies and bring environments that can help children in their recovery process?

3. Does the tangible interface promote social interaction, reflection and collaboration?

Chapter 3

Methodology

This chapter covers the requirements of the interface that was built, including the design methodology, sensors, microprocessor and overall structure of the interface. Additionally, data collection and analysis, research limitation and ethical considerations are also explained.

3.1 HCI Design Principles

Baecker, Grudin, Buxton, and Greenberg (1995) have described HCI as the "discipline concerned with the design, evaluation, and implementation of interacting computing systems". HCI focuses on three main components: the human, the computing system/machine/tool and the interaction itself. For the purposes of this research, it is crucial to understand the social factors, psychological and environmental factors of the combined interaction between humans and systems alongside the core design of the system [26].

3.1.1 Physical Computing Environment

To build effective interfaces and hardware systems, it is essential to explore and understand the social, physical and cognitive environments since such environments affect many aspects of an interface's design. Specifically, the ergonomics ("fitting the system to human" Robin Good, 2004) of the system had to be taken into account carefully for this project because the study mainly focuses on children. Therefore, a safe design that protects the participants' welfare and well-being need to be considered as well as accessibility and working space.

When designing the interface, the social environment which are hospitals and possibly homes in this instance, was taken into account, since the environment where the system is going to be used will affect how the user will interact with it. Solitary activities provide different results to the same activities done in a group. Cognitive aspects were also considered as they include fundamental psychological elements such as learning and problem-solving. Furthermore, other cognitive issues have been considered, in particular, technical knowledge, age and disabilities [26].

3.1.2 Collaborative Interfaces & Environment

Collaborative Environment is an interesting paradigm to explore as it allows groups to interact and engage with each other in direct and indirect methods. Hence, for the design of this interface, it was essential to consider whether the system will be used in solitary, in public or both. For this study, the design of the system is primarily aimed for individual use. But it also has the flexibility for it to be used in groups. Since, collaborative interfaces help to promote increase interactions, cooperative tendencies and even harmony in groups [27].

3.1.3 Core Design Principles for Human-Computer Interfaces

To create successful interfaces core design principles are useful that can be applied through various technologies. For the purpose of this research, four strategies were considered from Norman's (1983) work:

1. Designing based on the seriousness of the matter and developing an awareness that users of the system will have. Since good intentions do not always lead to good design

2. Providing methods and guidelines in a quantitative and/or qualitative manner. However, this rule can be broken within reason if explanatory design choices are being explored.

3. Providing software tools for interface designs. The Software can usually enhance and bring different systems (especially hardware-based interfaces) to life, and it can offer different possible usage of an interface that could have not be thought of before.

4. Creating a modular design, where interface design is separated from other programming tasks, taking into account both programming and human behaviour.

Other fundamental design choices consisted of striving for consistency where logical sequences of actions resulted in similar situations, informative relevant feedback are present for every operator action and permitting easy reversal of actions [28].

3.2 Sensors & Microprocessor

To develop the cube, multiple sensors as well as other hardware, were chosen to elicit different interactions. A combination of "medical" sensors were chosen as well as other sensors which promote a variety of playful interactions that can be viewed from figure 3.1. Additionally, each sensor acts independently and provides a unique experience and feedback to the user. The "medical" sensors also have a secondary objective that is to make the "real" measurements done with a clinician less intimidating and for the child to have a basic understanding and a sense of control of their well-being.

3.2.1 Galvanic Skin Response

The Galvanic Skin Response (GSR) is the measure for continuous variation in the electrical characteristics of the skin, e.g. caused by the variation of the human body sweating [29]. GSR analysis is based on how skin resistance changes with the state of sweat glands within the skin, and it is a measure of the human sympathetic nervous system responses. The Seeed GSR with Finger Sensors were used for this project since it could easily be used by children.

3.2.2 Pulse Sensor

The principles of a pulse sensor (heartbeat sensor) are based on photo plethysmography. This is a measure of the change in blood volume through any organ (e.g. a finger tissue) of the body which causes a change in the light intensity through that organ [30]. The pulse sensor uses a light emitting diode and a light detector resistor. By having variations in the flow of blood as a tissue is illuminated with the light source, it either reflects or transmits the light. The amount of light absorbed depends on the blood volume in that tissue. Electrical signals are the output of sensor which is proportional to the heartbeat rate. In this research, the "pulse sensor amped" was used which is a plug-and-play heart-rate sensor used for Arduino, which can easily incorporate live heart-rate data.

3.2.3 Force Sensitive Resistor

A force sensitive resistor (FSR) also known as a pressure sensor is a sensor that provides measurement of physical pressure, weight and squeezing. The FSR will change its resistance depending on how much force is being applied to the sensing area. The FSR used in this research is a 0.5" in diameter, sensing area which can sense applied force anywhere in the range of 100g-10kg.

3.2.4 Temperature

The temperature sensor used in this research is a one-wire ambient temperature sensor that provides 9-bit to 12-bit celsius temperature measure with $\pm 0.5\,^{\circ}\mathrm{C}$ accuracy over a $+10\,^{\circ}\mathrm{C}$ to $+45\,^{\circ}\mathrm{C}$ temperature range with the device having $\pm 2.0\,^{\circ}\mathrm{C}$ accuracy. It is a simple sensor that communicates over a one-wire bus which means it only requires one data line for communication with the microprocessor.

3.2.5 8x8 LED Matrix & RGB LED

The feedback of each sensor was presented on an 8x8 LED SparFun LuMini Matrix packed with 64 individually addressable LEDs. It provides a great way to create custom shapes and add a square of light for different purposes. The matrix uses a 2mm by 2mm package which allows for tight pixel density that removes pixelation. Furthermore, an RGB LED was also used for the final sensor, which uses the primary colours red, blue and green to produce over 16 million hues of light. Although it is not possible to create all colours, some of the colours are "outside" the triangle formed by the RGB LEDs.

3.2.6 Arduino

Arduino is an open-source micro-controller which can be easily programmed to create many different engaging hardware and software-based projects. To power and test bunch of the sensors stated above, an Arduino UNO board was used as the micro-controller for this research. Arduino is an efficient tool for research and academic works as they provide fast processing, straightforward interface and friendly in quick prototyping [31]. The Arduino seemed the best fit for this research since in this age the increased use of open source software and hardware, creating complex systems are more accessible to build and more enjoyable to use. Other reasons for the need to use an Arduino board and what makes it different to other boards are an active user community, the rapid growth of Arduino, inexpensive hardware and the multi-platform environment, so that projects can be developed and extended easily.

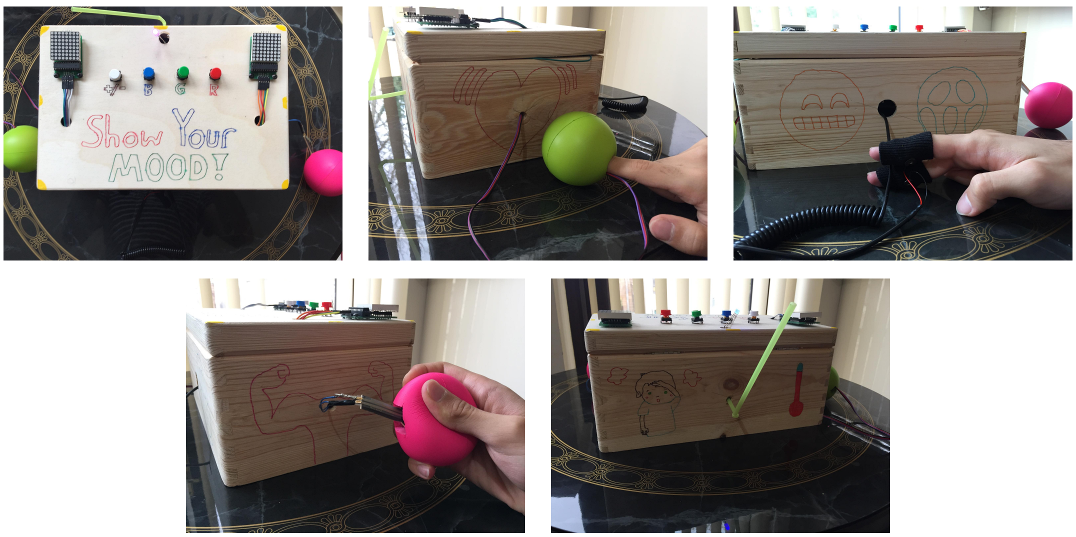


Figure 3.1: Different sides of the cube present different interactions. Top left: Mood Colour, Top Middle: Heart Rate, Top Right: GSR, Bottom Left: Pressure, Bottom Right: Temperature

3.3 Cube Design & Materials

A normal rectangular wooden cube was chosen for the project. A wooden base allows the cube to be strong enough to hold the electronics as well as a cheap material for reproduction. Inside the cube, all of the electronics would be stored with each side of the cube using one sensor. Other materials include colourful squeezy balls that are soft to press, a plastic straw, colourful buttons and the GSR sensor where a user can place their finger on. All the materials described are cheap but useful tools that can be replaced quickly and at the same time provide engaging interactions.

Simple designs were drawn on each side of the cube, mainly based on the feedback the user is going to receive on the LED screens. On top of the box, the user is promoted to **"Show your mood!"** using bright colours. Other sides contain drawings of relevant emoji's, a heart and a strong character flexing to portray. This design approach was adopted so that the cube does not prime the user too much in how they should use each side. A simple design promotes a more exploratory attitude as well as it gives the user a sufficient amount of space to be able to customise the cube to their personalised taste.

3.4 Interaction & Feedback

The materials chosen for the cube were considered so that every side provides a different, playful and appealing interaction. A combination of squeezing, pressing, blowing and feeling interactions are incorporated to increase the duration of the use of the sensors as well as maintaining engagement. Additionally, every sensor's goal is to regulate different emotions and feelings for a user, although, various sensors and their uses could be interpreted for mixed feelings based on the user.

The GSR sensor can help to understand the emotional and behavioural changes that occur within humans. Some mental states such as stress, nervousness, engagement and drowsiness can be drawn from GSR signals. The sensor could be used in a situation where a child feels they are in a nervous or at a time of an emotional situation.

The purpose of the pulse sensor is intended for occasions where children may be preparing for a check-up with a doctor or an operation. Or perhaps if they are excited or have completed an intense activity, they may be primed to check their heart rate and see how it has been affected. The sensor is placed inside a colourful squeezy ball, where a child can insert their finger into a small hole in the ball to check their heart rate.

The pressure sensor is intended for when a child feels angry or frustrated where it is placed inside another colourful squeezy ball. A child can squeeze the ball and based on their pressure and strength different feedback will be presented back to them. The temperature sensor is attached to a straw which a child can blow. By blowing into the straw, the temperature increases and outputs are given to the child through the LED screens on the box. The purpose of the straw is to add a different playful interaction where a child may want to use if they have a fever, a cold or if they are preparing again to see a clinician.

The RGB LED is used for children to be able to show their mood and how they are feeling through colours. The interaction with the button allows the user to *add* and *subtract* colours, and by doing so many different colours can be created and to easily recreate or rectify the colours produced.

Two 8x8 LED Matrix is placed on top of the box. One is designated to the pulse sensor which displays a flashing smiley face (based on your heartbeat) if it detects a *normal* heart rate and a flashing neutral face if it detects an *unusual* beat. The other is connected to the rest of the sensors. The temperature sensor after blown will show the word *hot*, to indicate the increase of temperature. The GSR sensor will show either a surprise or a nervous face, and the pressure sensor will show three different levels of feedback based on how hard you have squeezed the ball.

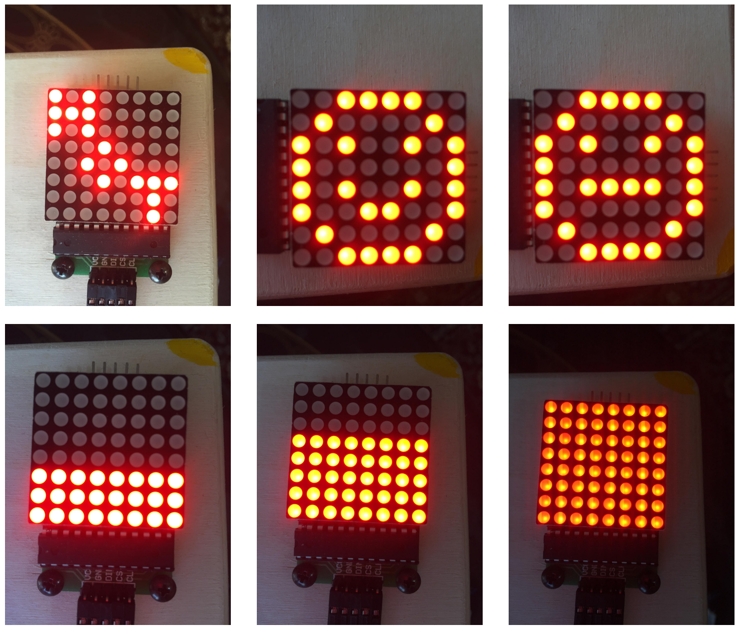


Figure 3.2: Some of the feedbacks show on the LED screen after interacting with the sensors. Top left: Hot for temperature, Top Middle and Right: Smiley face and neutral face based on heart rate, Bottom: Different outputs based on how hard you squeeze the pressure ball

3.5 Data Collection

Due to the nature of the cube and the sensors involved, many data points are created and collected. However, since most of the sensors used are not very accurate from a medical perspective, the raw data that is generated from the sensors are not collected. This is due to the fact that unreliable data i.e. from the pulse sensor, could be very misleading to medical staff and have to be calibrated correctly to each user.

Therefore, the data collection is through more indirect measures and more emphasis is put on the interactions with the cube. Different sides of the cube provide different feedback to the child. A child can choose to record the observed feedback by using designated stickers on a board personalised for them. In doing so, the researcher can track how a child uses the cube and what sensors and interactions are the most important to them. Additionally, the board can give clues on how a child may be feeling or felt before or perhaps what they identify most important about their wellbeing which can, later on, be shared with friends, family and clinicians.

3.5.1 Observation

Throughout workshops and meetings, direct observation was used to understand how different user groups interacted with the cube. Observational research is a helpful technique to see how individuals interpret the purpose of the cube, which features they find most interesting and playful and whether the cube was intuitive and easy to use. This technique used in a suitable environment can permit measuring what behaviour is like and may give a better representation of what frequently may occur.

3.5.2 Semi-Structured Interviews

In terms of observations within each workshop and focus groups, a short amount of time was dedicated to practise semi-structured interviews. Due to the fact of having a short time frame, semi-structured interviews are more efficient when there are no more than once chance to interview someone or a group. The interviews allowed the participants to express their views in their terms as well as providing reliable, comparable qualitative data. It also provided an opportunity for identifying new ways of seeing the topic at hand.

3.5.3 Focus Groups

A couple of focus groups were conducted to investigate the complex behaviour of how a group may interact with the cube. The focus groups provided information on how different groups think, feel and communicate about a topic and whether they hold individual opinions. Such differing views and ideas lead to understanding the effectiveness and usefulness of a particular sensor of the cube. Also, the opportunity to seek clarification about a broader range of information was provided within the focus group.

3.5.4 Workshop

Workshops are effective ways to engage relevant individuals who are interested in the proposed research and an inspiring way to get a message out into the world. Participants are usually motivated and often give honest and representative feedback. Workshops also allow the chance of participants to get involved closely to the research problem at hand where users are diving closely at finding, analysis and researching appropriate solutions. It is crucial to include children in a co-designing process which involves issues tackling their wellbeing.

3.6 The Young Persons' Advisory Group

The London Young Persons Advisory Group (YPAG) set up in 2006 aims to increase the input and influence of children and their families into the development of clinical research. The group arranged regular meetings every six to eight weeks with membership open to those aged 8-21. The children and young adults joining the group must have an interest in improving health research. The members come from a diverse background, some patients from GOSH, some related to GOSH staff and others who have taken part of clinical trials. The group is active in providing input to all stages of clinical research.

It is incredibly valuable and beneficial to involve young adults and children in shaping research for both the researchers and the members involved. Researchers have been impressed by the quality of the feedback received, deep and relevant insights and the observations obtained from the members of the group. YPAG has also helped researchers improve study designs by highlighting what is necessary and acceptable to them. A workshop was organised with children aged 9-18 at GOSH with the YPAG group to involve children for the design study of the cube as well as receiving feedback on the prototype.

3.7 Play Specialist at GOSH

The play specialist team involves a child-focused expert team often linked between home and the hospital. After working and understanding each child and family individually, the team works to provide a fun and enjoyable environment that is tailored to the needs of each child. Additionally, they help the patient's family to manage with the experience of a loved one in hospital.

Every ward at GOSH has its dedicated play team and play rooms. Every morning, a play specialist visits children at their ward and ensures that there is plenty planned for the day to keep everyone engaged and busy. The team also tracks for any special events that are coming up such as birthdays so that patients do not miss out on the experience just because they are in the hospital. A meeting was organised to get the view of the experts from GOSH about the proposed cube.

3.8 Limitations & Ethical Considerations

Due to the scope and time frame of this research, certain aspects of the cube were designed to verify the credibility and feasibility of this technological probe. One limitation of this project is the size of the cube. A larger cube was developed due to the limited time to print out the electronic circuits and interference of some sensors that were joint together. The weight of the cube is also considered too heavy for a child to carry since additional power banks are used to power the microprocessors.

Additionally, the outer layer of the box was kept wooden, but it could be changed to different materials that could enhance the touch and feeling sensory of a child. The shape of the cube could also be altered which can increase the engagement of the user, such as changing the edges of the cube. Moreover, the data produced by all of the sensors used in this projects proved to be inaccurate and were only useful as an approximation; hence, no real or live data is collected and the data collected is through the feedback given the user, who can keep a diary of their results.

This research aims at children around the ages of 6-12 years old who are currently hospitalised. However, due the ethical procedure to access such children takes longer than the scope of this project, the evaluation of the prototype has been compromised through children between ages of 10-18 who may have been hospitalised before (i.e. have gone through similar experiences) as well as the play specialist team at GOSH which will be explored in the next section.

Chapter 4

Findings

To evaluate the effectiveness of the cube different strategies of assessment were adopted at different stages of the study with a wide range of people. An agile methodology was adopted where the requirements and solutions evolved through collaboration with different experts and cross-functional teams. This section will provide an outline of how the prototype was evaluated through four methodologies consisting of observations, semi-structured interviews, focus groups and workshops. The evaluation considers HCI experts, parents, university students, children as well as expert clinicians.

4.1 Evaluation Methods

After the completion of the first version of the prototype, before continuing and iterating the development process, the different inputs and outputs was tested through semi-structured interviews and a focus group to gather whether different components of the sensors made intuitive sense. The interviews and focus groups consisted of university students some specialising in HCI.

4.1.1 Interview

The interviews conducted at this stage focused mainly on the effectiveness of the individual components and to assess whether each component made intuitive sense based on certain contexts and situations presented to them. Additionally, each individual was encouraged to comment on the feedback of the cube as well as any other improvements that could be made to create a better or more playful experience. The participants of the interviews included six of university students ranging from different backgrounds and some specialising purely on HCI. A context was set for the participants to imagine whether they would use the sensors in certain scenarios. The context for evaluating each individual is presented below:

- **Mood Colours -** When a child feels a certain emotion for example feeling unhappy, bored, lazy, fearful or sad
- **Pressure Sensor -** When a child feels physically weak, angry or frustrated
- **Heart Rate -** When a child feels excited, or whether they are going to be checked by the doctor on that day

- **Temperature** - When a child is feeling ill or has a high temperature
- **GSR** - When a child is feeling stressed or nervous

The participants were then asked to interact with the cube for each scenario with every sensor during the interview. The following questions were then asked in order to each participant:

1. What do you think about this sensor?
2. How do you feel about it after using it?
3. Does the outputs make sense?
4. Do you think children will like it?
5. How would you improve the interactions or experience?

At the end of the interviews each participant was also asked to rank in order of their preference which sensors they liked and disliked the most in respect to its usability and playfulness (where 5 is the highest and 1 the lowest). Figure 4.1 highlights the rankings of the most and least preferred sensors by each participants labelled from A-F. The results show that Mood Colour and GSR sensor were well liked amongst most of the participants scoring highly. The heart rate and the pressure sensor were the third and fourth most liked sensors, however, their existed a few participants whom they did not like the interactions. Lastly, amongst most of the participants the temperature sensor was the least preferred.

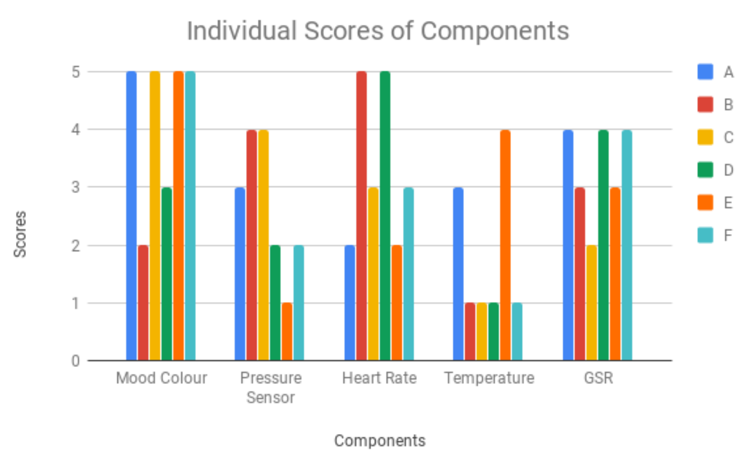


Figure 4.1: Individual scores of each component given by each interviewee (labelled from A-F) where 5 is the highest score given and 1 being the lowest. Each score was obtained after a participant had tried all of the sensors and asked to rank them. Each score was obtained in regards to usability and playfulness

Mood Colour

One of the main points raised by the interviewees about the mood colour was that it was viewed less about the *body* and more of a mental exercise. The participants mentioned how it prompted them to think about their day and self-reflect as they interacted creating different colours. It was mentioned that having instructions would be beneficial suggesting how to use the buttons to create the colours. For some people picking a colour may be arbitrary, their favourite one or the colour they saw on that they. Since the meaning of colour could mean anything, asking the child what their mood is could result in more *relevant* results.

Overall, it was considered that children might want to know what moods each of the colours represent rather than having to choose for themselves. In particular, there should be some method of understanding what a colour would mean, perhaps either prompted previously that certain colours should have certain attributes or through conversations with the children themselves. A participant noted that in the beginning the colours did not meant anything to him but after playing with it for a longer period of time they understood it better and reflected more about their interactions and similarly the other participants found the component interesting and satisfying to use.

Pressure Sensor

Initially the pressure sensor had no casing and the full sensor was visible when interacting with it. The first interviewee suggested that having a sensor without any casing on top of it could be intimidating for children. For the other interviews, a ball was used to cover the sensor and instead of squeezing the sensor itself, the user would squeeze the ball. Overall the majority of the participants found the squeezing fun and playful. It was also appreciated that there was a direct correlation between pressing the ball and receiving instant feedback.

Some interviewees mentioned that it is hard to exactly understand whether we can find meaning from the results of the squeezing or how it would be interpreted exactly. Having said that some participants mentioned that there is meaning based on how often perhaps someone uses the sensor depending on how they are feeling and this could be explored further. Most people felt neutral about the feedback presented depending on how hard you squeezed the ball, however, another interesting suggestion was the addition of sound and animation. It was also mentioned that instead of having fixed values, the current pressure could be normalised based on the first pressure, hence creating a dynamic and changing threshold based on different users.

From a childs point of view, the pressure sensor could be viewed as too playful where a child may just squeeze the ball without the intention of its purpose. Although it could also be argued that usually there lies a reason of why they would want to squeeze the ball (i.e. when they are bored), which in itself is a form of reflection.

Heart Rate

Similarly to the pressure sensor a ball was also used to cover the sensor, this time a participant would be able to insert the finger into the ball to check their heart rate. This sensor was widely liked because of its simplicity and intuitive use of it. All the interviewees enjoyed the feedback of the smiley face to show that they are "*okay*" and that it portrays the meaning well.

Ideas about sharing and comparing your heart rate with other people that have the cube were mentioned. Similarly multiple heart rate sensors could be used to compare between individuals to see who is calmer or less stressed. This would lead to more interactions between the individuals and can act as a conversation opener with others.

Children (especially the ones in hospital) would perhaps find it more relaxing and feel they have ownership over their well being when using the heart rate sensor. This is because usually for most medical check (e.g the heart rate or blood pressure) a more complex procedure is undertaken where a child does not understand nor has any control over what is happening.

Temperature

The participants interacted with a temperature sensor with their fingers by pressing onto it. By doing so the temperature of the sensor increased and the feedback presented to them wrote *hot* on the LED matrix. Collectively the participants found the interaction with the temperature much less engaging, interesting and too simple in comparison to the other sensors. Most participants did not enjoy the interaction of holding/pressing the sensor and did not find it intuitive at first at what they had to do with it (they had to be told beforehand on how to interact).

Most participants felt neutral about the output shown, however, one mentioned that *hot* is more of an objective term and perhaps it should be more abstract and open ended. Additionally, to make the experience of using the temperature sensor more playful, some participants suggested that if you blow on the sensor, it makes the experience more interesting. One participant mentioned that they use their hands to interact with most things in their day to day life. So by blowing into a straw, this provides them a more engaging when another modality is introduced such as the mouth.

Since children in general are more curious and adventurous, with the addition of a straw there are elements which can be intriguing. Using another sensory element to use the cube should make the children more engaged and interested where they can explore different types of interactions to make the experience more memorable.

GSR

The GSR sensor was considered the most unique component as well as *feeling* the nearest to a medical sensor. Most participants found the sensor interesting and fun to use as well as calming and more reflective. The reason is that it was considered similar to the heart rate sensor which subconsciously promotes encourages thinking.

On the other hand a child may find the GSR sensor hard to understand and could react to it as a *motion sensor* rather than a sensor determining whether their has been any significant changes towards their arousal levels (i.e when they are stressed or nervous). Also the feedback could be misleading sometimes, for example if a "*shocking*" face is shown, this may not be the true mapping of what the person may be feelings as emotions are generally subjective. However, the feedback was appreciated to show that an emotional change was detected.

In summary most of the sensors made intuitive sense to the participants and the interactions were regarded appropriate for their purpose. A few mentioned that some of the sensors felt silly when they were using it but suitable for a child. The outputs were also fitting with a few suggestion of making it more *dynamic* such as adding animation. The participants usually wanted further guidance and explicit meaning from the interaction they were involved with. Most of the time they had the idea of understanding precisely what measurements were be taken and how they could view the data. However, a main distinction about children and the participant would be that children might not want to have precise guidance or meaning in an activity they are engaged in. In general children would rather like to be free to choose for themselves how they interact as well as gather their own interpretations of how things could be perceived.

4.1.2 Focus Group

A small focus group of 4 university students was also conducted to measure how multiple people would interact with the cube. During the session, they all tried using different components of the cube, leading to them engaged in different conversations about either the meaning of their interactions and other ways of using the cube. For example, when using the Mood Colour a conversation was started when a participant asked how a certain colour could be created and whether it would be possible. This conversation lead onto which "*difficult*" colours could be created within the room.

Additionally, conversations arose around the heart beat sensor as well as the pressure sensors where certain members of the group compared how hard they could squeeze the pressure sensor as well as talking about how they were feeling when they were using the heart rate sensor. An interesting observation was made when certain members of the group randomly tried and went back to specific sensors they previously experienced during the times that they were not engaged in a conversation and when formally the focus group ended. On top of that they became more interested every time a member found something new when interaction which made them use the sensors once more.

4.2 Preliminary Workshop

A trial run of the workshop for the YPAG group was done with a group of HCI PhD students at University College London to understand the best methodologies to use in order to gather feedback about ideas on how to measure and express wellbeing with children. The focus of this workshop was around the prototyping exercise and how to best present early prototypes.

The group was split into two groups of 3 and 4 where each group was given 15 minutes to come up with a prototype of a new technology that could enable children to reflect on their wellbeing. Each group designed a prototype in the allocated time (figure 4.2 shows the participants at work with their prototypes) and then presented it to the rest of the team which are described below:

Group 1

Wearable/smartwatch with display that shows symbols representing wellbeing that can be displayed to another person or a friend with the same watch. The team considered form of representation as emojis, smileys, weather, hashtags and personalised representations, where an individual has their own "*language of symbols*".

Group 2

Representing emotional states by classifying a child's behaviour together with parents (who know the child the best) so that it can be translated in common descriptors that health professional can understand. An interface that could serve this could be hospital name tags.

Key takeaways from the session were to add an introduction before prototyping session and to make sure that everyone was clear about the task at hand. It was also noted to ask children to provide an example situation when they found it difficult to express their feeling as well as presenting them examples/scenarios which they can think about when designing their prototypes. The prototyping activities were also considered by the group to be appropriate for the children to conduct.

Figure 4.2: Group of HCI PhD students participating in the preliminary workshop designing prototypes ahead of the YPAG session

4.3 YPAG

The prototyping activity was designed for the children based on the outcome of the pilot workshop run with the PhD students. The workshop was planned so that after the design activity the children were invited to interact with the cube and were asked more specific questions.

4.3.1 Workshop Specifics

The workshop consisted of one YPAG organiser, 2 Nurses, 4 researchers and 16 children and young people aged between 10 to 19 year olds. The workshop lasted approximately around 45 minutes, where the first 7 minutes were dedicated to an introduction from the UCLIC team and the context for the workshop as well as explaining the activities we planned for the afternoon.

My role in the workshop consisted of taking care of one group and providing guidance whenever they required when building their prototypes. I also gathered feedback from all the groups and their creations as well showing a demo of the cube at the end of the session. During lunch time a few short interviews were also conducted as well as giving the children a chance to interact with the cube. Two scenarios were discussed before the prototyping activities to give a better idea to the children about how they can think about the task at hand. The scenarios that were discussed:

Joe and Jane are 9 years old and they are feeling unwell

- *Joe is not feeling well at home or at school.*
- *Jane is not feeling well in the hospital.*

Those around Jane and Joe such as their friends, family, nurses and doctors really want to know how they are feeling to be able to help them feel better.

After presenting the scenarios a description of the activity was given to the children:

Imagine you are in their shoes and want to be able to capture how you feel and share it with others. How would you design this as a tool for yourself and your friends?

Using a prototyping technique that is common for co-designing with children, design teams of 4 were created. Each team received a large bag filled with supplies such as stickers, glue, paper, markers, and scissors as shown in figure 4.3. Each team would then develop one prototype with the help of UCLIC team to engage and take notes being discussed during the activity.

4.3.2 Workshop Results

he prototyping exercise proved to be very successful as many creative, imaginative as well as thoughtful designs were created by the children. The children cared a lot about their designs and gave much thought when considering different age groups and children with different abilities.

(a) Supplies provided to each group **(b)** Children engaged in creating prototypes

Figure 4.3: Prototyping activity where each group is involved in creating a *solution* to measure their own or others wellbeing

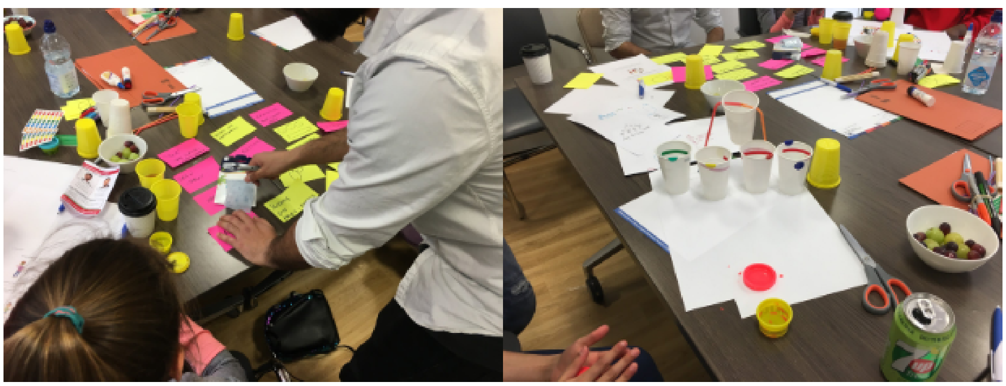


Figure 4.4: An example of two groups in the making of their prototypes

Group 1

This group created a *suggestion box* where users can put different colour balls to show how they are feeling (e.g. very unhappy, unhappy, happy and very happy). The group focused on creating a playful experience but at the same time they wanted the design to accommodate for different age groups. They also explored the idea of creating a product that can both be personal or used in different wards within the hospital.

Data triangulation was also explored since the children were using more than one method to collect data on the same topic. By doing so they were assuring the validity of research through the use of using multiple methods to collect more data on the same topic. This is where on the other side of the box suggested words can be written where users can circle at the back, to enhance the meaning of their mood.

Group 2

This group designed containers where a ball can be thrown into them from a short or long distances. Inside the containers there would either be a button or a sensor that would notify a clinician about the state of their mood when a ball is placed inside. Different feelings can be identified through the use of different colours. Similarly to group 1, this group focused on creating a playful interaction such as throwing the ball and communicating feelings without directly speaking to anyone. An interesting takeaway was the particular attention paid to patients who may be older or have disabilities or incapability of throwing where a remote control would activate the different features.

Group 3

The design of this group consisted of a large touch screen that would be placed on a large wall in different wards/rooms around the hospital. The touch screen would aggregate the data about feelings of individuals in that ward and their reasons. Sharing emotions could be revealed anonymously if someone is not feeling comfortable to reveal their identity. The purpose of this design evolved around seeing stories from other people who were in the ward at different times, which showed a sense of connection and empathy. This results to connecting with others in reflecting on ones own health, i.e. if 90% of people feel unhappy, you may feel less alone in how you are feeling. It can also open up opportunities to opening up to people around you about your feelings.

Group 4

The design process of this group started from the idea of having mood diaries to record an individual's feeling. A virtual mood diary called "*Bob*" that uses AR/VR technology that children can talk to share their feelings and emotions. This could be a virtual animated figure that can be prompted when a child decides to share their emotion and "*Bob*" can be *transported* to different wards. This virtual figure could also have a physical appearance that you can have by your bed side or in bed with them which emphasises the personal emotional attachment that it could create.

Other interesting topics that arose during the prototyping session were around data privacy and that a person should always have control over when they want to share their data. Similarly, many of the children liked the idea of personalisation and to share about their wellbeing without the need of speaking to anyone.

4.4 Workshop Feedback on the Cube

After the prototyping session a demo of the cube was shown to the groups. General feedback was gathered about one thing they liked and disliked about the prototypes. The positive and negative general feedback about the cube are shown in the table 1. The cube was seen to be playful and fun and most of the children really enjoyed having instantaneous feedback. Some negative feedback mentioned the box should be more ergonomic meaning eliminating factors that cause discomfort. Improvements would be to use a softer material for the cube and rounder edges. Other suggestions such as adding your own custom design, different outputs of LED and addition of music for the visually impaired were put forward.

Positive	**Negative**	**Other Suggestions**
Playful and Fun	Should be More Colourful	Adding Your Own Designs
Interactive	Should be More Portable	Different LED Feedbacks
Instant Feedback	More Ergonomic	Addition of Music
Personalisable	Cube Too Big	
Avoids Boring Writing	Heavy	

Table 1 - General feedback received about the functionality and design of the cube

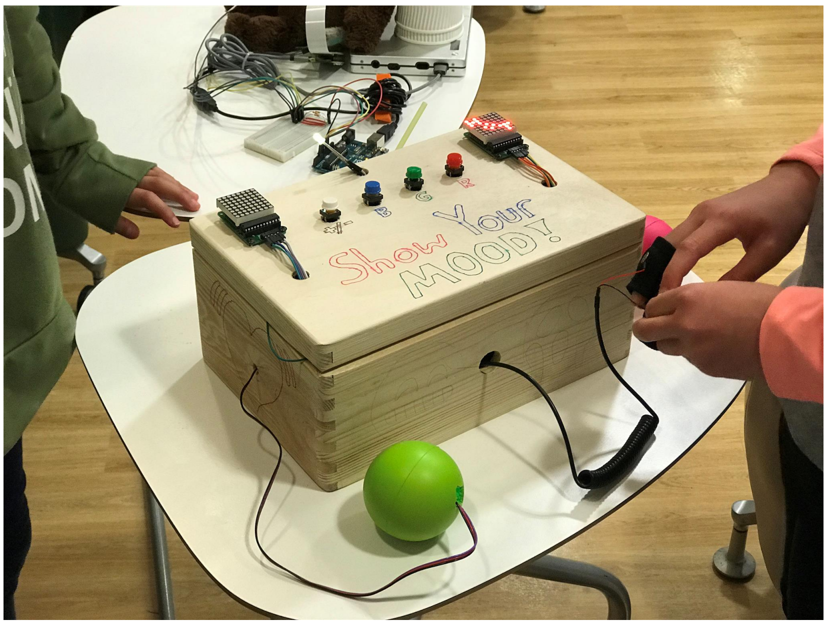


Figure 4.5: Two children interacting with the cube, one using the GSR sensor

After receiving general feedback from the groups, a relaxed semi-structured interviews were conducted asking more specific questions of the children to understand deeper about the purpose of the cube.

Reflection

When asked whether the cube helps them to think about how they feel or whether any interaction with the sensor help towards self-reflection, the heart rate sensor and the GSR sensor were considered the most favourable as it provides a discrete way of reflecting about ones own health. The heart rate sensor was also highlighted as it would help focus bringing attention to their breathing.

Most children agreed that the cube could be used based on how they felt on particular days as a way of assessing their wellbeing. Some said they might use it every day just like a diary to capture their mood and some would only use it when they feel particularly different.

Communication

Most children viewed the cube as a personal device where they have full control of how they use and interact with it. Many of the children agreed they would mainly want to use the cube at their own leisure and not particularly with anyone else. When asked about sharing any of the results/feedback of the sensors with the clinicians, friends or family, most children were open about this idea, however, only when they felt the need to.

Younger children aged 9 and 10 proposed the idea of having a monthly or yearly chart where they would record the feedback of the sensors. One child in particular thought that a chart would make her reflect more about her health where she can analyse how she feels through the weeks of the year. At the same time the children were open to share their results with others, but again only when they feel the need to and not as an order.

Health

The cube's purpose is to try to accommodate towards many different feelings and emotions a child may be facing. Table 2 shows which different sensors are preferred for a particular feeling. The mood colour would be used when a child is feeling lazy, bored or unhappy. It enables them to explore and portray their feelings through a creative activity of creating different colours that represents them the best at that moment. When feeling frustrated or angry many expressed they would use the pressure ball, as a way of getting rid of their frustration, since the ball was also satisfying to press.

In the occasion of a child feeling stressed or nervous, most children preferred the use of the GSR and heart rate sensor. This is because such sensors were *more calming* and discrete to use. When asked about how they would use a cube if they knew about visiting a doctor soon or if they were about to go through certain "checkups", the heart rate, GSR and temperature were favourable. This is due to the similar interactions they may have when they are being examined i.e. attachments to their fingers for measurements and blowing medical tests for measurements of breathing.

Other Comments

Some specific suggestions were also made towards the functionality of the cube. Different visualisation feedback such as the use of animation, were proposed. Moreover, many of the children recommended the cube to be portable, this enables them to have an emotional connection and ownership of the cube which results in using it more often. Furthermore, the idea of an avatar appearing on a screen e.g. jumping around and looking happy or slouching and looking sad were also liked since it made the cube more exciting.

Table 2 is a summary of the mappings mentioned by the children as to which sensor best matched which mood. As can be seen the pressure ball was linked with negative moods, such as anger and laziness. The GSR and the heart rate was mostly linked with measuring anxiety and nervousness but also boredom. Lastly, the mood colour was the most diverse sensor that was linked with measuring various number of moods such as nervousness, boredom, laziness, frustration and unhappiness.

Unhappy	**Frustrated**	**Angry**	**Stressed**	**Nervous**	**Bored or Lazy**
Mood Colour	Pressure Ball	Pressure Ball	GSR	GSR	Mood Colour
Pressure Ball	Mood Colour	-	Heart Rate	Mood Colour	GSR
GSR	-	-	-	Heart Rate	Pressure Ball

Table 2 - Feedback from individual interviews and workshop based on which sensors would be used for different emotions

4.5 Meeting with GOSH Play Specialist Team

A follow-up meeting was then organised with half of GOSH Play Team (approximately around 20 members) demonstrating the cube prototype as well as having an open discussion about three main areas:

- In what situations and environments would this kind of device be useful?
- Discussion of the idea to use the prototype as communication facilitator (supporting interaction and communication between medical staff, patients and family members)
- What usage do you see for this kind of device between the different stakeholder groups, for instance, clinicians, patients and family members?

The cube was in general perceived to be a very positive and useful tool that could directly be used in a hospital environment. One of the key situations that the cube was mentioned, that was not considered before, could be very useful for was for: pre-operative assessment, use before going to theatre, post procedural and training/prep for surgery. In addition to that the cube someone mentioned it could be used before coming to the hospital to get used to medical equipment as it would help reduce anxiety.

For pre-op assessments, the team usually goes through certain questions usually about previous experiences, whether they had operations before, if they had gone to a hospital, finding out more about their background and of their family and what they are generally worried about when coming to the hospital (i.e not liking needles). One expert shared (p1)"*...we would see them at pre assessment and they would talk about their feelings and anxieties...you usually find out more about them at the end, details about their anxieties are usually shared...*". Assessing anxiety levels, or checking with long term chronically ill patients to see how they are feeling as it will change during different points in their admissions.

Another expert added (p2)"*...the cube can make them more at ease during pre-assessment and they can play around with it, they have their heart rate taken during pre-op, blood pressure done, so it could be used as a learning tool as well as understanding why their heart rate is going up and down...*". The cube persuaded to be really useful for children who may not normally express emotions and find it hard to speak out as well as bored children in hospital beds and autistic children. Non-verbal/withdrawn children can benefit from the cube to let the team know if they are worried, one member told (p3)"*...I had a patient who was so worried, the only way I knew he was scared was by squeezing my hands...*".

Currently, the team uses play charts with smileys that represents *happy* to *unhappy*, and the cube provides an interactive method to see the interactions. It is also appropriate for a child whos going through care for chronic condition, surgery and long term admissions. They may have talked about their emotions in the past or participated in the pre-op exercises. But to have another method of communication, one more tool that may make the child respond to more than what is just asked of them, this can yield much more meaningful results. It was also revealed that the devices could be used in all the different types of wards in the hospital and even useful to use in outpatient areas as a distraction mechanism.

The cube also introduced a way of indicating connections about feelings and emotion and a way to learn to control them. The cube in particular was used as an example for regulating emotions, it provides tools to help with anxiety or control breathing and the children could see the direct effect through the visuals and the feedback from the cube, in other words making the invisible, visible.

It also became apparent during the discussion that parents of the patients want to know exactly what doctors know, i.e. in regards to the usage of sensors measuring their child, although presented to them in a different way. Sometimes doctors could forget this transition and get lost in too many technical details which may not be comprehensible for the patients parents. One of the play experts said (p4)"*..Parents especially with older patients but sometimes with younger ones too, patients check with their parents what they are worried about, therefore, having something between the patient and the parents can be a good way of communicating with each other...*".

Some challenges that the cube could present for young children were also discussed. Children who do not have a good *grip* might find the pressing of the ball hard to use, hence, other alternative features such as pressing a button or a touch interaction would be more suitable. If a child has visual needs, a feedback that incorporates sound can be useful. Lastly, hygiene should be taken seriously in a hospital environment even if a child has their own device. The cube should not increase the chance of risk infection and it has to be tested and approved by the hygiene standards (the blowing into a straw was seen as most problematic).

Chapter 5

Discussion

This section will provide a critical discussion about the benefits and disadvantages of the proposed cube alongside analysing the different stakeholder involved. Different domains will be discussed from the use of the cube in different environments, the types of interactions as well as future work and how it could be further developed and scaled.

The aim of this study was to understand and interpret, how a novel tangible device the cube - could be used to measure the emotions and feelings of children in regards to their wellbeing through interactions. Additionally, this study focused on how indirect play HCI methodologies can help to design tangible interfaces that can help children in their recovery process as well as to promote social interaction, reflection and collaboration.

5.1 Tangible Physical Computing

The findings of this study supported the idea that the cube design with multiple physical input and outputs was effective for assessing a childs wellbeing through their interactions. Due to the geometry of the cube, different sides facilitated different interactions that children can engage with. The benefit of having multiple different sensors was that it enables children to be more engaged when interacting with the cube giving them the opportunity to learn about and reflect on different aspects about their own wellbeing. The results showed that the level of complexity of the sensors used were appropriate as well as applicable feedback presented back from each sensor.

The cube was fit for purpose for all ages, although different age groups reacted and used the cube differently. The finding that older children cared more about privacy than younger children does not mean it is any less important. If anything it is the opposite: is important to be mindful that the cube protects their data and how it is stored since they may be unaware of what it means to share their data with others and whom.

By building a physical probe that children can engage with they were able to express themselves in ways that you are not able to within traditional methods such as surveys or using mobile phones. In contrast to traditional methods physical probes create immediate feedback, clear instructions and obvious in what it represents. By having multiple new components enables more scope for children to express different feelings, allowing more opportunities for thoughts, exploration and reflections.

The finding that younger children dived in more suggests that at first they saw this more as a toy to be experimented with. However, after an initial exploration they then began reflecting on how to use it for the purpose intended. Therefore, allowing young children time to become familiar with such a device is important to consider before using it to collect data about their wellbeing.

Although there were many positive notes about the cube there were a few limitations mentioned about the form factor. One comment that was often repeated was that the cube was dull. But the reason it was designed to be this colour was to be neutral and avoid the cube to be seen as a toy. During the YPAG meeting many of the children mentioned that they would prefer a more vibrant and colourful design and something they can make their own. Yet making it colorful might have suggested it was meant to be played with. As a way round this there could be an opportunity for children to colour and dress up the cube themselves using materials provided. The materials provided could also be softer so they feel good to touch. This kind of customization could improve increase the time spent with the cube.

5.1.1 Size

The size of the cube can present different functionalities and purposes within different environments. Due to the electronic constraints the cube was designed so to be stationary and not fit for much movement. Most children preferred a smaller portable cube that's lighter which makes it easier for them to carry with. A portable cube would enable more frequent interactions throughout the day which can result to a better understanding of their wellbeing. As well as a chance for the children to personalise the device.

On the other hand, a larger cube can provide more functionalities and it is easier to maintain. Additionally, a larger cube would promote a higher public engagement and curiosity that could lead to collection feedback from a wider audience. Different cube sizes would also determine in what environments they would be most effective. Smaller sized cubes would fit the purpose of individuals where they would interact with in private, whereas larger cubes would mainly be in public and encourage direct collaboration with other.

5.1.2 Potential Tension of Playfulness

The studies reviewed in this project highlighted how novel and playful interactions could provide insightful insights about the users and the task in hand. The findings support the idea of introducing playful interactions and a user-centered design. Early involvement of users feedback on the prototype helped in informing how to create a device that children could relate to. During the YPAG workshop every prototype created by the children involved in some way a playful activity as otherwise any other type of design would be considered less appealing and boring.

However, it is often difficult to arrive at a balance of designing probes that have the right amount of playfulness without creating gamification and diverging from the purpose of the device. It can be seen from the Mood Squeezer study (Gallacher et al., 2015) that certain participants felt the interaction was too childish which meant they decided not to engage. During the YPAG workshop no child in particular found any of the components of the cube too childish to use nor they were embarrassed to use it. The younger children seemed to enjoy the different types of sensors and the older ones engaged more with the "*complex*" sensors.

Due to the fact that the children at YPAG are volunteers who take time out from their own free time to contribute for research, they may have been more respectful and thoughtful when using the cube than other children. Hence, if the cube was exposed to different age groups, backgrounds and environments, the reactions could differ. For example, other children may find it too playful, which results in using the cube only for play rather than reflection about ones wellbeing.

5.1.3 Data

During the meetings and the workshops the cube was presented as a kind of probe for eliciting responses from the participants, meaning no real data was recorded or processed when a user interacted with it. Since the accuracy of the sensors proved to be inaccurate and noisy, no meaningful *medical* information can be recorded. Having said that, other types of data can be recorded which may enhance the additional meaning. The focus of this study was on designing and evaluating the efficacy of different forms of physical computing for creating a novel monitoring device. Future research could investigate what data and in what form could then be collected using this form factor.

Some examples include, how often a user interacts with certain sensors, whether they travel with the device, at what time of the day they use the device and how much time a user spends on certain components. Other measurements such as how hard they press the ball or blow the into straw could also be recorded. Although gathering more data can provide better insightful results, further ethical clearance and data privacy would need to be investigated, especially in the context of health and children.

5.2 Design Implications of Cube

Firstly, Since the cube is intended for children and it is used within a health environment, safety and robustness are fundamental aspects that should be prioritised over everything else. Since the patients are already in undesirable situation, the device should put their safety at first as well as minimising any effects of risk infections.

Secondly, the sensors should be designed in a user friendly manner so that if in an occasion a sensor is failed, it is without any hassle that parts can be replaced. The choice of sensors should also be sensible based on whether the cube is going to be used privately i.e. by an individual or if used in a public space. Since if the cube is designed to be exposed to the public, more care needs to be taken in regards to cleanliness and the use of the individual sensors. Moreover, different feedback and sensors such as the use of sound should be accommodated for different children that may have visual needs or lack of grip.

Lastly, when designing for children, different appearance design approaches should be considered based on the age. It became clear quickly that younger children had a different preference of how the cube should look like than some of the older children. For example the use of brighter colours and even different material than just plain wood. Different coloured materials like plastic and fur would be more ideal.

5.3 Study Limitations

Due to the time restriction of the project and the long process of the ethics applications, this study was unable to perform user testing with young patients at GOSH. Also the workshops were performed with children only aged between 10-18, whereas children aged between 6-10 years old would have likely elicited quite different responses. It is important to consider which age group such a tangible device is most suited to although ideally it could be all. Im addition, the children participating at the workshop were volunteers who were interested in health research that may not be representative of children who are ill. Other demographics of children should be considered to have a less one-sidedness view. Finally, no actual physiological or mood data was collected due to the timeline of this project, therefore, the main focus was gathered around qualitative analysis and only a small amount of quantitative analysis was conducted.

5.4 Future Work

The observations and interviews indicated clear benefits of having a smaller cube, therefore, a restructure of the electronic architecture and the use of power supplies could achieve this. The findings from the study suggest that a virtual character might be a good addition, playing an effective role of showcasing more engaging feedback. By interacting with different sensors of the cube, a connection could be created with an application with the virtual character. This could be extended to multiple cubes collectively change aspects of the virtual character. This idea expands on the themes of collaboration and restores a feeling of community where different interactions results in changes through a virtual character. It is possible than to collectively view how the users are feeling as a whole. This approach could connect children in the hospitals not just at GOSH but around the world.

5.5 Self-Reflection

Reflecting back to the beginning, an enthusiastic meeting with Professor Yvonne Rogers kick started this project with multiple interesting ideas floating around. After coming up with a cubic approach and having numerous meetings with multiple experts within the HCI department at UCLIC and GOSH, a plan was made to develop a novel idea to improve children's wellbeing in hospitals. I was honoured to be given such an opportunity to have such freedom in my project as well as having support from leading experts in the field of my study. I am also grateful that I was involved in such a meaningful project and contributing in workshops within GOSH to understand and learn about the everyday problems of children and how we could improve them. I hope this project has contributed a small amount in helping to understand how we could understand more about children's wellbeing as well as providing them with interesting alternatives.

Chapter 6

Conclusion

This research explored the creation of a novel and interactive cube that helps understand emotions and feelings of children in regards to their wellbeing through interactions. Specifically, by using indirect play methodologies the tangible cube shows promising results in the end promoting self reflection as well as social interaction in regards to a child's wellbeing. The cube was well received with children as well as the GOSH play specialist team. The findings showed that different components of the cube helped children express themselves differently about how they felt. Also, the cube was mentioned to be applicable in many different areas such as pre-op assessments, pre and post surgery as well as helping children to regulate their emotions.

To accomplish these goals a numerous qualitative user centric research was used in different phases. At first feedback was gathered for each individual component of the cube through semi structured interviews and focus groups. The aim of this study was to understand and improve whether each sensor were used for the right purpose. In addition to that a workshop and a focus group were organised with YPAG and GOSH play specialist team. Various interesting tendencies were emerged from the findings showing the diverse practicality and characteristics of the cube. The cube also facilitated as a communication tool that could be a bridge between communication from the child to their parents or a clinician.

Design implications were made to reflect and improve on the design strategy while keeping the strength of the current design as identified in this study. To further better understand the well-being of children as well as connecting a community of children in hospital, the future study can focus on a data centric approach to connect physical interactions with virtual environments, where children anywhere around the world can interact with each other.

Bibliography

[1] L. S. Kokab Bsiri-Moghaddam, Mahdi Basiri-Moghaddam and F. Ahmadi, "The concept of hospitalization of children from the view point of parents and children," jun 2011.

[2] E. Commodari, "Children staying in hospital: a research on psychological stress of caregivers," may 2010.

[3] "Gosh - who we are." https://www.gosh.nhs.uk/about-us/who-we-are. Accessed: 2019-03-30.

[4] "Play information for parents and visitors." https://www.gosh.nhs.uk/wards-and-departments/departments/clinical-support-services/play-information-parents-and-visitors. Accessed: 2019-03-30.

[5] L. C. J. Ana Luca Norea PeaI, "The experience of hospitalized children regarding their interactions with nursing professional," nov 2011.

[6] S. Jani, "Impact of digital technology on social interaction within a household," jun 2017.

[7] "Teaching your child to: Identify and express emotions." http://csefel.vanderbilt.edu/familytools/teaching$_e motions.pdf. Accessed : 2019 - 04 - 30$.

[8] G. K. K. V. L. Jennifer G. Sheridan, Ben Short, "Exploring cube affordance: Towards a classification of non-verbal dynamics of physical interfaces for wearable computing," jan 2003.

[9] J. B. Eva Hornecker, "Getting a grip on tangible interaction: a framework on physical space and social interaction," pp. 437–446, apr 2006.

[10] N. Y. L. N. G. R. N. M. Zuzanna Lechelt, Yvonne Rogers, "Inclusive computing in special needs classrooms: Designing for all," apr 2018.

[11] G. G. H. K. Emanuel Vonach, Marianne Ternek, "Design of a health monitoring toy for children," jun 2016.

[12] E. Grnvall and N. Verdezoto, "Beyond selfmonitoring : Understanding non-functional aspects of home-based healthcare technology," p. 587596, 2013.

[13] P. Dourish and S. Bly, "Portholes: Supporting awareness in a distributed work group," 1992.

[14] J. B. Y. R. L. C. D. H. P. M. Sarah Gallacher, Jenny O'Connor, "Mood squeezer: Lightening up the workplace through playful and lightweight interactions," mar 2015.

[15] H. Brignull and Y. Rogers, "Enticing people to interact with large public displays in public spaces," vol. 3, 2003.

[16] R. Tieben, "Activating play a design research study on how to elicit playful interaction from teenagers," apr 2015.

[17] A. G. O. Z. Ofir Sadka, Hadas Erel, "Tangible interaction in parent-child collaboration: encouraging awareness and reflection," jun 2018.

[18] C. G. Connie Golsteijn, "Voxbox: A tangible machine that gathers opinions from the public at events," jan 2015.

[19] S. M. Janet C Read, "Using the fun toolkit and other survey methods to gather opinions in child computer interaction," jun 2006.

[20] P. V. C. Sarah A. Burgarda, "Challenges of health measurement in studies of health disparities," apr 2014.

[21] V. M. C. M. H. A. O. P. Blaine A. Price, Ryan Kelly, "Feel my pain: Design and evaluation of painpad, a tangible device for supporting inpatient self-logging of pain," apr 2018.

[22] A. Ben-Arieh, "Where are the children? childrens role in measuring and monitoring their well-being," pp. 573–596, dec 2005.

[23] A. Ben-Arieh, "Measuring and monitoring the well-being of young children around the world," 2006.

[24] J. H. Funk, J. and J. Schimming, "Children and electronic games: A comparison of parents and childrens perceptions of childrens habits and preferences in a united states sample," p. 104118, 1999.

[25] J. H. Funk, J. and J. Schimming, "Children and electronic games: A comparison of parents and childrens perceptions of childrens habits and preferences in a united states sample," pp. 883–888, 1999.

[26] R. Valverde, "Principles of human computer interaction design," jul 2011.

[27] R. L. A. M. Maaz Nasir, Kelly Lyons, "Cooperative games and their effect on group collaboration," 2013.

[28] D. A. Norman, "Design principles for human-computer interfaces," pp. 1–10, dec 1983.

[29] J. A.N., "Galvanic skin response measurement and analysis," jun 2015.

[30] "Heartbeat sensor working application." https://www.elprocus.com/heartbeat-sensor-working-application/. Accessed: 2019-01-30.

[31] L. Louis1, "Working principle of arduino and using it as a tool for study and research," vol. 1, apr 2016.

Appendix A

Workshops

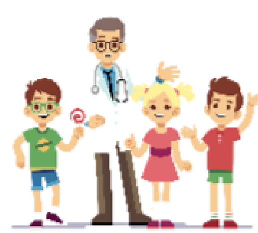
Co-design scenario v01

Joe and Jane are 9 years old and they are feeling unwell

Joe is not feeling well at home or school

Jane is not feeling well in the hospital

Those around Jane and Joe such as their friends, family, nurses and doctors want to know how they are feeling to be able to help them feel better.



Activity:

Imagine you are in either Joe's or Jane's shoes and want to be able to capture how you feel and share it with others.

How would you design this as a tool for yourself and your friends?

Draft Questions for Workshop and Meetings:

- **Reflection**
  - When using the cube, does any interaction with the sensors help towards self reflection? For example does it help you think about how you feel? Or does it help you focus about your breathing?
  - Do you think the device could be used each day as a way of assessing how well you feel?
  - Do you think any of the sensors help you to go back each day, that helps you think about how you feel?
- **Communication**
  - Would you share any of the results/feedback of the sensors with GP, friends and family?
  - Could you see yourself using the cube with GP, friends and family ?
- **Health**
  - What sensor would you use if you are feeling sad or unhappy?
  - If you feel frustrated what sensor would you use?
  - If you feel weak what sensor would you use?
  - If you feel angry what sensor would you use?
  - If you know you will be visiting a doctor soon or if you're going to go through certain "checkups", how would you use the cube?
  - Do you think the cube would be a good way to express how you felt if not feeling well?
  - How do you think the cube would be used to determine if you are feeling stressed?

Parents/Clinicians

  - How would a clinician use the cube? What would they benefit from it?
  - Would a parent use the cube with their child? If so what features would they find interesting? How would they communicate?
  - Could the cube be used in a public area, such as the reception area of a hospital?
- **Other**
  - How else would you visualise the feedback?
  - Would you want it to be portable?
  - If the output from interacting with the cube was an avatar appearing on a screen would that be engaging . For example, it could jump around and look happy or slouch and look sad.
  - , would that make the output more interesting?
  - What would you change about the interaction with the cube?

Workshop with GOSH Play Team

Note Transcript

Other challenges

- Hygiene could be a challenge with the current prototypes [even if they have their own device] → needs to be tested etc.
- For certain patients redesign how things (e.g. ball) need to be pressed and pushed - e.g. that you can put the whole hand instead of grip force

In what situations* do you feel these devices will be useful?

- Can be helpful for shy patients who do not want to speak to you and for whom non-verbal communication (touch/gesture etc.) is easier
- wards
- Pre-op
- Long-term conditions

(… And situations where these devices should or can not be used?)

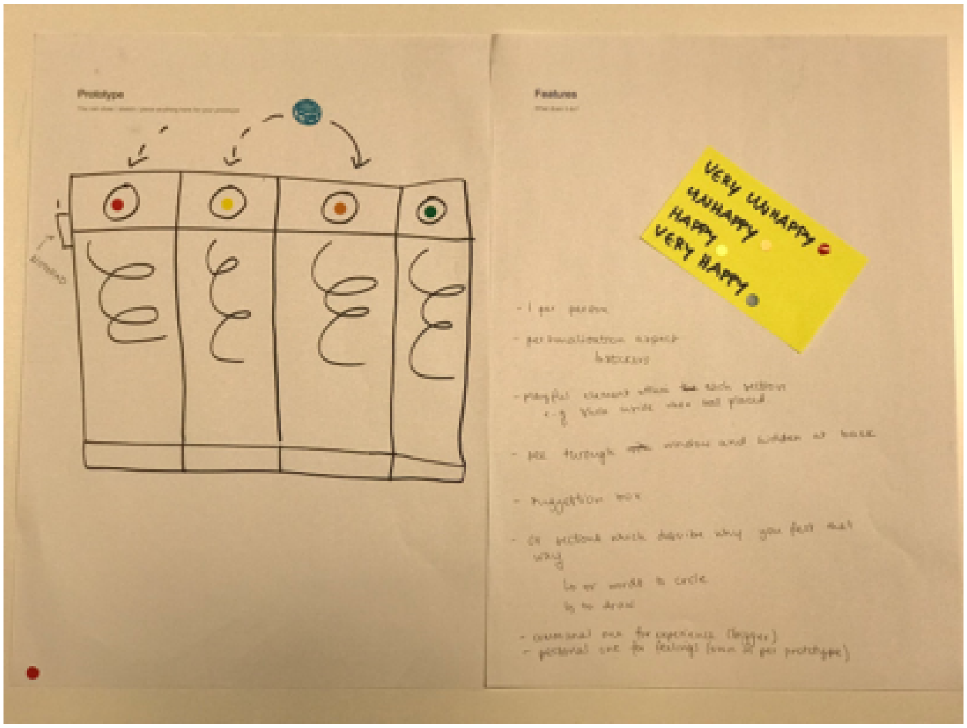
- Strength of patient's grip - it could be too hard to squeeze

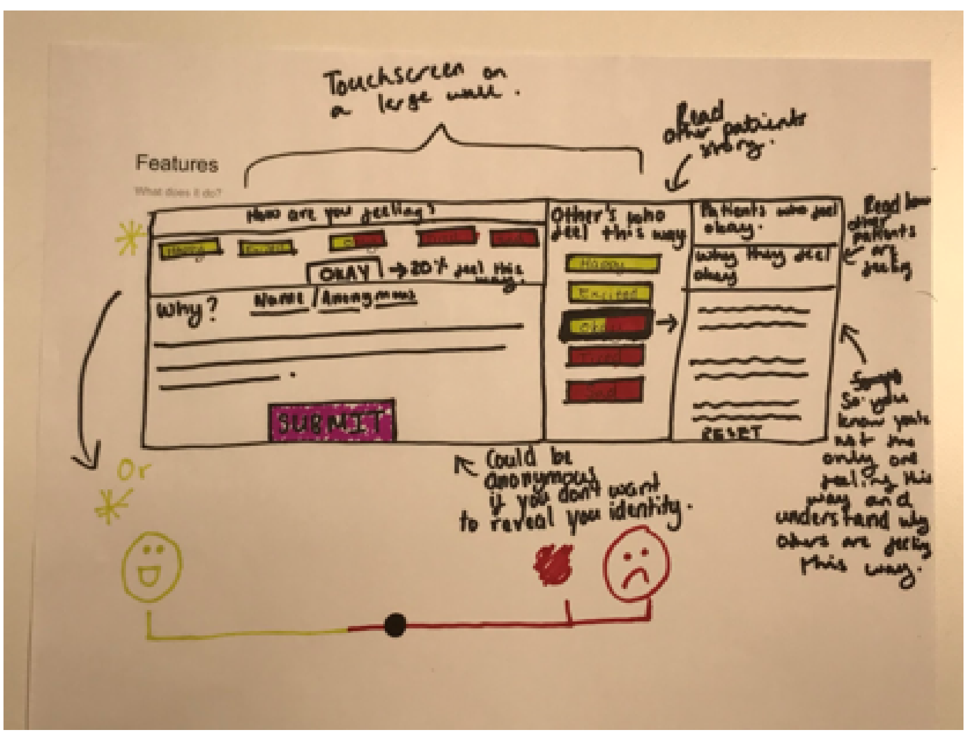
How can you see these devices to aid communication for example in being a "facilitator" — supporting interaction and communication between clinicians, patients and family members?

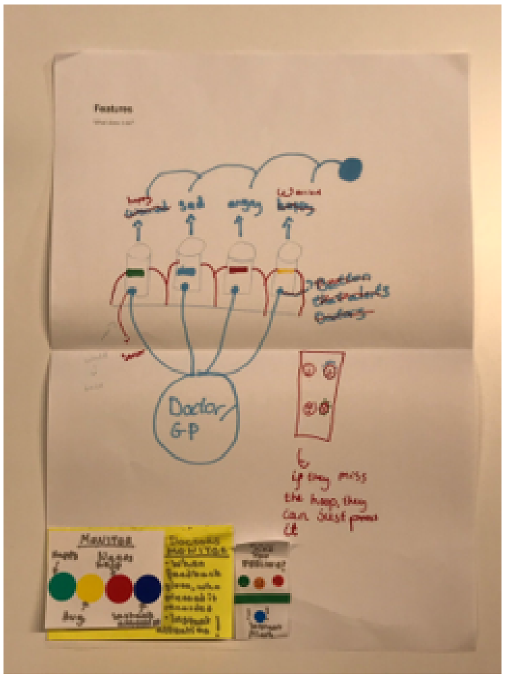
- Use in preassessment when they need to speak to the patient about their background, fears of hospital/medical devices etc. → such a device could make them feel more at ease in the discussion with the staff
- Referring to cube → it can be good to regulate emotions (by looking at the cube and its visuals/feedback etc.)

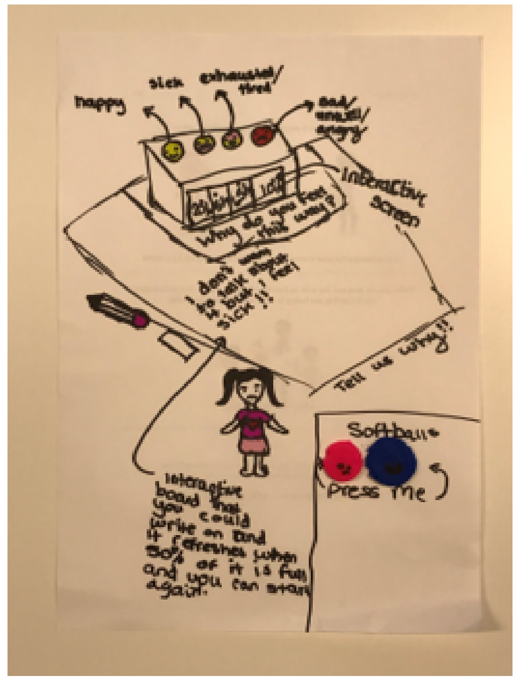
What usage do you see for the devices between the different stakeholder groups, for instance, clinicians, patients and family members?

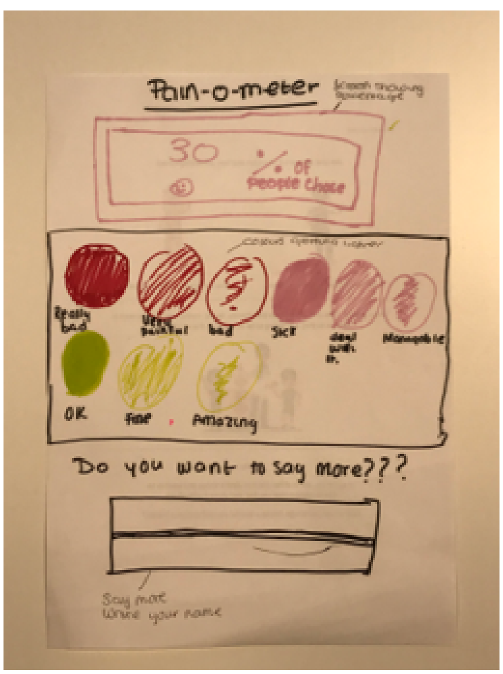
- Parents want to know the same as doctors but they need to be told in a different way
- Can facilitate communication between parents/doctor and the child

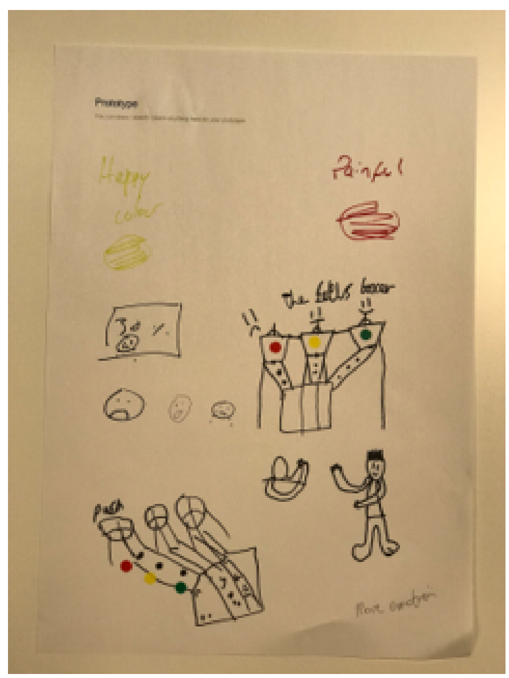

Prototype
Features
VERY UNHAPPY
UNHAPPY
HAPPY
VERY HAPPY


Touchscreen on a large wall.
Features
What does it do?
Read other patients story.
How are you feeling?
OKAY
Why?
Name / Anonymous
SUBMIT
Other's who feel this way
Happy
Excited
Patients who feel okay.
Why they feel okay
RESET
Could be anonymous if you don't want to reveal you identity.
So you know you're not the only one feeling this way and understand why others are feeling this way.
Or


Features
Button characters
Doctor GP
if they miss the hoop, they can just press it
Monitor


happy
sick
exhausted/tired
sad/unwell/angry
Interactive screen
why do you feel this way?
I don't wanna talk about it but I feel sick!!
Tell us why!!
Softballs
Press me
Interactive board that you could write on and it refreshes when 80% of it is full and you can start again.


Pain-o-meter
30
% of people chose
Really bad
Very painful
bad
sick
deal with it
Manageable
OK
fine
Amazing
Do you want to say more???
Say more
Write your name


Prototype
Happy color
Painful
30 %