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Children Designing Serious Games

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Abstract

It has long been a tradition in interaction design to involve users in order to better capture user needs and preferences. The involvement of children as informants and design partners is well documented for interaction design but its use in serious games design is much less reported. Where children are contributing to the design of learning materials their knowledge may be incomplete. This paper reports on the organisation of, and the deliverables from, a participatory design activity with children in which they were charged with designing a game for children in another continent. The study found that children predominantly focussed on the learning aspects of the serious game during their design activities but they were also able to consider some of the game aspects. They demonstrated understanding of instruction but were less aware of some of the other aspects of learning including feedback on understanding. Involving children in the design of the serious game lead to some nice insights that were included in the game that was subsequently built and shipped. Taking Müller's third place in HCI as inspiration, the paper concludes with some reflection for how to involve children in serious game design.

Keywords: serious games, participatory design, children, tablet

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1. Introduction

Having end users participate in the design of their eventual artefacts is a facet of a user centred approach to design (Blomberg & Henderson, 1990). Originally inspired by the work of the participatory design (PD) and socio technical design researchers (Muller, 1991), the involvement of end users in early ideation and in specific design tasks is now firmly embedded in Human Compuer Interaction (HCI) (Grudin & Pruitt, 2002).

Traditional participatory design is a set of theories, practices, and studies related to end-users as full participants in activities leading to software and hardware computer products and computer-based activities (Greenbaum & Kyng, 1991), (Schuler & Namioka, 1993). More recently Michael Muller wrote of participatory design as being able to infill a 'third place' in HCI design which is not about the workers (or users in a games based context), nor about the software developers but is about an in between region sharing attributes of both parties (Muller, 2003).

Third places, or hybrid places, as described by (Bhabha, 1984) offer many opportunities including inbetweenness, co-creation of languages and ideas, mutual learning, and emphasis on collectivity. In designing for children in rural Africa, and in designing an artefact that crosses games and learning, this present study uses children in the UK as the third space for participatory

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design insights with the aim to gain insights as to how to design and develop an engaging serious game.

This paper therefore begins to explore the area of participatory design in this space, of designing a serious game for children in another culture with children from a UK culture. The aim of the study presented here was to focus on the design aspects of this experience by investigating to what extent participatory design with children could be used in the design a serious game. The research team were interested in the extent to which children could capture design requirements for learning and fun.

The paper is organized in six sections – in the first section, literature relating to the use of participatory design with children and for the design of serious games is presented. This is followed by the motivation for the present work and a description of the design event, the following section presents a summary of the analysis of the designs that the children delivered and this is followed by a brief section outlining how these designs were used in the eventual game. The discussion section revisits Müller's third space in HCI and offers some insights as to how children can be facilitated to design in the space of serious games design.

2. Related Work

Participatory design with children in the context of HCI is an area that has been well studied in the literature. Studies tend to focus on the philosophical arguments around the practice, on methods to facilitate children's involvement and on the products and ideas that are generated during PD sessions.

Philosophical arguments tend to focus on the role of the children and on the extent to which they can participate in meaningful design activities. Participation of children is not exclusively discussed within HCI, the social sciences have long considered this with influential works by (Hart, 1992), who suggested a ladder of participation from tokenism to citizenship, from (Sinclair, 2004) who provokes discussion on the one-off participation of children as opposed to more sustained involvement and from (Christensen & Prout, 2002) who discuss the roles of children and put forward a case for ethical symmetry as a minimal requirement even if there cannot be a power symmetry. In HCI, some of these themes have been taken up by the Interaction Design and Children (IDC) community – the roles of children as participants in HCI work has been modelled by (Druin, 2002) suggesting children can be participants, informants, testers or users, participatory power imbalances were discussed by (Read et al., 2002) who delineated participatory design activities with children along an axis from informant through balanced to facilitated design and the ethics of children's participation in design activities has also been studied by (Read & Fredrikson, 2011) who made a case for children being given full information about the potential use of, and the funding for, the designs that they contribute.

In terms of methods for participatory design with children, several methods have been described including co-design (Churchman, 1968), design partners (Druin, 1999) and informant design (Scaife, Rogers, Aldrich, & Davies, 1997). Each of these approaches varies in its motivations and focus but the core aspect of all is the engagement with the user group and the facilitation of design activities by research teams who deliberately delegate much of the design activity and power to the participating user team. As participatory approaches have become more commonplace, many researchers have sought to develop methods to facilitate the process, as reported in the review paper by Jensen and Skov (Jensen & Skov, 2005), and have sought to investigate and develop techniques and tools for the interpretation of the design artefacts that may be produced. The IDC community has carried much of this work out, where it is postulated that the involvement of children, as end users and as informants, is especially pertinent as their ideas may be some distance from the ideas of adult designers.

The effectiveness of participatory design in terms of gathering ideas and inspirations form children is also discussed within the IDC community. Here research seeks to identify methods by which ideas can be generated, as in the mixing ideas approach found in (Guha et al., 2004) or to explore the idea generation process (Mazzone, Read, & Beale, 2008b) or to consider how PD can be used with specific user groups or specific design challenges. User groups that have been shown to be able to participate in design activities include very young children (Marco, Cerezo, Baldasarri, Mazzone, & Read, 2009) as well as teenagers (Mazzone, Read, & Beale, 2008a). Products for which participatory design has been shown to work have primarily been functional products including web sites (Read et al., 2002) and digital libraries (Theng et al., 2000). The application of participatory design with children in the area of serious games is less prevalent – this is discussed in the following sections.

Heuristic definitions of serious games can be attributed to several sources, some time before games were digital, n his book 'Serious Games' Clark Abt wrote "*we are concerned with serious games in the sense that these games have an explicit and carefully thought out educational purpose and are not intended to be played solely for amusement*" (page 9)(Abt, 1975). There is considerable discussion as to the application of the term 'serious games' to digital games but several sources suggest that it was Ben Sawyer in 2003 who first made this connection (Sawyer, 2003), one which, in 2006, was significant extended in terms of the 'educational purpose' of a serious game in the seminal book by (Micheal & Chen, 2006). This extension included education, training and informing as all legitimate activities for a serious game.

The development of digital games, and more particular of digital serious games, follows a lifecycle approach that

is not entirely dissimilar to the approaches used in general software development although there has to be some adjustment for the design of the learning. In this regard, deFreitas (de Freitas & Jarvis, 2006) propose a seven step design process applied to serious games that begins with a user elicitation process that includes 'semi-structured' interviews with individuals from targeted user groups. Stage two of their process is the codification of cases, stage three is validation by experts, stage four is the development of usage scenarios, stage 5 is the user requirements report, stage 6 is the formative testing and evaluation with user groups and the final stage is iterative testing with users for each pilot version. It is evident that user involvement is central to many of the stages but this can be problematic if there is no feasible access to the user group. This problem hints at the use of surrogates, this being an established practice in user studies (Ritter *et al. 2000)* and, to a lesser extent, in participatory design (Schuler & Namioka, 1993).

Participatory design of games with children is reported in the literature but has not been specifically studied in serious games design. Children participated in the POwerball design (Brederode, Markopoulos, Gielen, Vermeeren, & de Ridder, 2005) by virtue of interviews and then concept evaluation and the authors recorded that full PD would have been ideal had they had more time. PD for learning products with teenagers was used by (Danielsson & Wiberg, 2008) in the design of a His and Hers game that was used to explore gender issues at school. Similarly, and also with teenagers, (Mazzone et al., 2008a) used participatory methods to design a game to instruct teenagers in emotional intelligence. These two, and similar studies, were having end users designing 'for their own kind; and were with children in high school where the expectation was that they would have some knowledge of how to construct learning materials. The Danielsson et al. paper suggests that the main contributions from the teens were in terms of game content (words and characteristics for the on screen players), aesthetics, and Experience. There is no evidence in the paper that they especially contributed to the design of learning. Mazzone et al tell a similar tale with most of the ideas coming from the teens being associated with game play.

The specifics of designing serious games with children is an area that is awaiting study. Of interest in this space is the extent to which children can consider learning aspects and games aspects in a single design activity. The interdependency between the different aspects as reported in (Frank, 2007) include overlaps between engagement, context and training objectives.

3. Study

The study that is presented here aimed to design a serious game for children in Uganda in Africa that would eventually be implemented on a small 7 inch Android tablet. The aspect of this study that is specifically reported in this current paper is an investigation of the extent to which the children were able to contribute to serious games design in a participatory context. Specifically the participatory design activity was using surrogates for end users and was taking a third place philosophy. The children engaged in the design would be required to

a) design learning into the game
b) design fun into the game
c) design for a population that was not their own but was aligned to their own
d) communicate designs in such a way that a software developer could understand them

The overall success of the design activity would eventually be measured in terms of the success towards all of these aims across the activity but for this study, in this paper, the focus was on the extent to which the children could describe and design a serious game – viz items a) and b). Two groups of children were considered for the participatory work, children aged 8 and 9 and children aged 10 and 11. Both groups would be given a similar outline to the work to be done and evaluation would be based on the end products from the design studies.

3.1. Procedure

The research team organising the event had previously decided to focus the game on hand-washing seeing this as a topic tat could be approached with fun but was also important enough for the children in Africa to care about. Using the classification from (Ratan & Ritterfeld, 2009) this game idea was described as follows:

- Educational Content – Health
- Principle of Learning – Knowledge
- Age – Elementary School
- Platform – Mobile Tablet

Carefully completed hand-washing is known to be highly effective at reducing sickness and in hot countries, where running water and electricity is scarce, effective hand-washing is a life-saver. Estimates from UNICEF suggest that as many as 1.6 million children die each year from poor hygiene associated with not being able to wash (UNICEF, 2003).

The design session took place in a light room at the University with around 15 children at a time. Four sessions were held in total, two with each age group and in total, 51 children participated. The sessions took around 45 minutes and the children worked in groups of two, three or four as suited themselves. Teachers and researchers were on hand to encourage the children in their work but they were instructed to not influence the design ideas.

The first author of this paper prepared a brief presentation that was given to the children at the start of the session outlining what they had to do. This informed the children of the seriousness of water borne diseases and highlighted that 1 child dies every 20 second from a

water-related illness; children in the design sessions were asked to raise their hands if they had washed their hands that day and the vast majority of children indicated they had; they were then given instructions on how to wash their hands properly including the counting method of making sure all fingers and the wrists were washed, after this they were re-asked as to how many actually washed their hands properly, it was interesting to note that the majority of children put their hands down at this stage. The stages of hand washing that were given to the children were:

- Wet hands
- Add soap
- Wash for 10 – 15 seconds – wrist fingers, nails
- Rinse well
- Dry with towel
- Turn off tap with the used towel

Children were then given a brief overview of how to design a game using the following prompts:

- Make it fun
- Comfy
- Fingernails
- Sing? 15 – 20 seconds
- Fill in chart
- Doing things in the right order?
- See and do, copying
- Pictures of germs

The children were then shown the technology upon which the game would be built before being split into groups (this was done by the teachers) and were then provided with paper to storyboard their game and a variety of coloured pens and crayons. The paper that was given to them was pre printed with four 'landscape screens' to help the children think in the context of the tablet device. In line with best practice on working with children, flexibility in the design space was encouraged. To that end some groups of children opted to create an individual game whilst others worked collaboratively in a group with one person assigned to draw and write the instructions following a group discussion. To assist the children researchers acted as facilitators providing encouragement and positive feedback.

4. Children's Designs

All of the children who engaged with the activity either within a group or individually managed to produce a game related to the subject specified in the design brief. In total 50 drawings were produced by the children. The drawings indicated a varied assortment of ideas for the game including simple animated stories, interacting via touch with objects such as taps and soap in order to act out the process of hand washing and interactive games focussed on removing germs from hands as shown in Figures 1 and 2.

Figure 1. Childs drawing of a hand with germs on

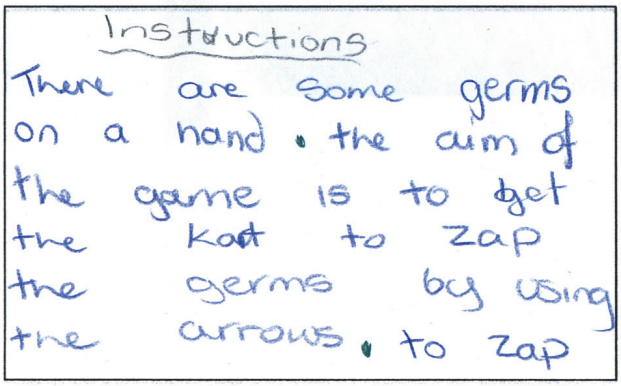

Figure 2. Child provides instructions on how to play

As would be expected the quality of the drawings and level of detail provided varied between groups, Figure 3 shows an example of a drawing that is difficult to convert into a gaming context. It would appear that the user needs to click on the soap to put it on his or her hand but from a gaming perspective it is difficult to distil the challenge, or other attributes such as fun, from this design.

Figure 3. Child drawing of soap being used

4.1 Analysis of Children's Designs

The analysis of children's drawings is an established method in the area of child-computer interaction (Xu, Read, Sim, & McManus, 2009). In the present work, the drawings from the children were analysed in two different contexts. The first context, in order to investigate the extent to which children are able to design game or learning elements into the game used the the fun heuristics of Malone (Malone, 1981) and the e-learning heuristics from (Alsumait & Al-Osaimi, 2010) to score success in this regard. From these two heuristic sets a set of criteria for identification within the drawings was extracted; in terms of fun and game play these criteria were:

- Goal (the clear existence of a goal for the game)
- Fun add-ons (things just for fun like sounds etc.)
- Rewards (for game progress and game success)
- Desirable child centred content
- Randomness to provide surprise

In terms of learning, six criteria were chosen from the learning aspects of the heuristics and were:

- Organisation of the learning material
- Formative feedback on learning
- Appropriate language (even as images)
- Consistency of learning presentation
- Interactivity (to increase engagement)
- Knowledge (imparted through the game)

The children's designs were then inspected, one at a time, by two of the authors and a binary coding system was used where the existence of one of the above criteria within the design was scored 1, the non-existence was scored 0. Thus – the maximum score for a single game would be 11 (all criteria present), the minimum score would be 0.

The second context for investigation and analysis centred upon the third space as discussed in the introduction. Muller (Muller, 2003) claimed that certain attributes are relatively common across practices within participatory design these being inbetweenness, questioning assumptions, and heterogeneity, therefore these formed the basis of the second coding scheme with the criteria being used being:

- Inbetweenness – highlighted as the evidence of elements that were not about hand washing.
- Questioning Assumptions – evidenced by either new game play or new learning ideas
- Negotiations – where there was evidence of group collaboration within the designs
- Heterogeneity – demonstrated by the number of different interpretations of the concept that were formulated by the children.

For the two criteria inbetweenness and questioning assumptions the same coding scheme as for the game and learning heuristics was used where the existence of one of the above criteria within the design was scored 1, the non-existence was scored 0. Negotiations wee scored in terms of groups - a score was given of 1 if two or more designs were more or less identical, with the presumption that they had worked individually but the design idea came from the group. The final category heterogeneity was established by allocating each drawing into a theme using an open-card sorting technique based on similarity, such as if the drawing was a straight linear narrative of how to wash your hands. These themes emerged during the card sort and both researchers participating in the card sort had to agree that it belong to a certain category, consensus was eventually reached for each drawing.

5. Results

Of interest in this study was the extent to which children could be facilitated to design a serious game. The results were analysed to establish whether children could provide game and learning elements as well as an analysis of how the ideas relate to the 3rd space, thus the results are presented separately.

5.1 Children's capacity to produce game and learning elements

The scores were totalled for each characteristic relating to either games or learning and these totals are shown in table 1.

Table 1. Totals for each characteristic

Game Features	Totals
Goal	17
Fun	16
Rewards	19
Desirable	19
Randomness	13
Learning Features	**Totals**
Organisation	31
feedback	5
language	29
consistency	31
interactivity	16
Knowledge	23

As can be seen from table 1, even when an account is made of there being more learning categories than game categories, the children produced designs that had almost twice as many learning features than game features. The mean score for the gaming elements was only 16.8 with a standard deviation of 2.49 whereas the score for the

learning elements were 22.5 and the standard deviation was 10.35.

5.2 The 3rd Space

Table 2 below shows the total number of images of categories for each of the elements within the 3rd space.

Table 2. Totals for each element of the 3rd Space

3rd Space Elements	Totals
Inbetweenness	11
Questioning Assumptions	21
Negotiations	5
Heterogeneity	14

The results shown in Table 2 would suggest that by and large children tended to follow the specific task, with only 11 items being coded against inbetweenness. Thus the majority of games drawn followed closely to the overall theme and did not introduce novel ideas. Examples of items that were coded to inbetweenness included a game play that allowed for painting your nails, a game that started with a skipping game (which made the hands dirty) and a game that started with the player playing with his or her dog.

As evidenced by the score against questioning assumptions, almost half the children were able to come up with new game or new learning ideas with 21 reported cases. Example of these included zapping of germs with a gun and searching for various items, including soap, in a where's wally type environment, to enable washing of hands.

In terms of negotiation it was evident that children had discussed their ideas with their peers and several had drawn identical games. For example multiple games were based around angry birds, around a girl sneezing, the use of germ spotted hands, germs associated with flies and a quiz with the option to check answers.

In total 14 unique 'game' ideas were identified within the context of heterogeneity. Table 3 below shows the ideas that were identified and the number of drawings relating to this theme.

Table 3. Number of unique ideas and the total drawings

Ideas	Totals
Straight linear instructions	16
Linear with a reward	9
Nonsense	7
Spotty Hands	6
Sneezes	3
Individual Ideas	9

The items which were categorised as nonsense were based on the fact that it was impossible to determine how to play the game or it did not relate to the overall context of hand-washing. Therefore the three elements which were judged to be important to take forward into the eventual design were the straight linear instructions, the use of rewards and the feature of spotty hands.

6. Developing the Game

As stated earlier the game was intended to be developed for an Android Tablet. Before development occurred one of the researchers spent time with the software developer analysing the drawings to establish core themes which could be translated into the game. This analysis was additional to the analysis presented in this paper to also establish common graphical elements, storylines, means of interaction and gaming elements such as timers or highest scores.

Figure 4. The Game Entry Screen

The game begins with a short animation that instructed the children about how to wash their hands (figure 4) and the need for hand washing. This animation lasted 2 minutes and 14 seconds and was designed to address the linear narrative identified in the heterogeneity analysis in Section 5.2.

Interactive activities were then incorporated using the game ideas from the children in particular the spotty hands and the reward system. The game interface is displayed in Figure 5 where the children had to clean the hand by touching the 'dirty spots'. This portion of the game has 6 levels and the child has to touch at least 12 of the 26 germs within the time frame to progress to the next

level. For each germ they touch the children gain 5 points and every time they click they also lose soap, the soap runs out after 30 clicks; should this occur the child can buy more soap at a cost of 20 points. As the child progresses through the levels the timer, which starts off at 30 seconds, is reduced by 5 seconds, thus the child has to get better at germ zapping.

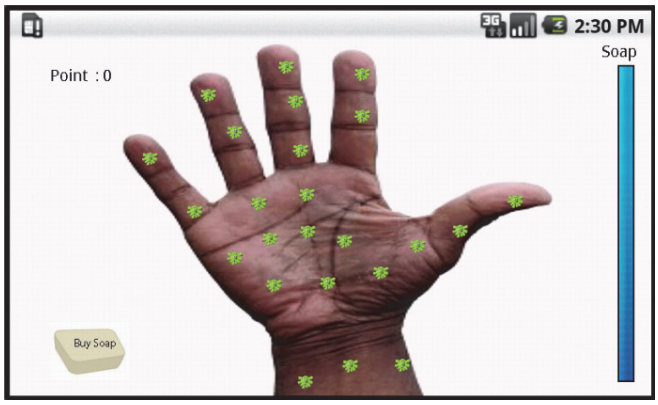

Figure 5. An interactive part of the game

In the designs by the children, game rewards were also identified as an important element. In the implemented game the reward system that was developed focused on the children gaining animals for their zoo. This idea appeared in several of the children's designs and was considered neutral enough for use with children from another country the zoo screen is shown in Figure 6.

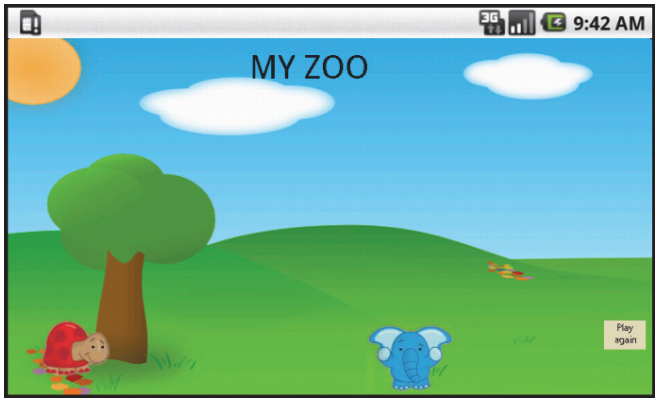

Figure 6. The zoo screen where children are rewarded for their work in the game

In total there were nine animals that could be bought for the zoo ranging from a snail for 50 points and a tiger for 115. The game as described was implemented in Java, installed on Android tablets and taken to Uganda in Africa for children to play.

6. Discussion

A participatory design session was conducted with children in the UK, which resulted in the development of a serious game to instruct and inform children in Africa about hand-washing. All the children managed to successful participate in this activity by completing a drawing to varying degrees of usefulness, judged on the researcher's ability to extract meaning from their drawings. Although some of the drawings were coded as nonsense in the 2nd analysis (didn't describe a game idea) each had contributed to elements such as fun in the 1st analysis stage and so there was some meaning from every drawing.

It is evident from the results in Section 5.1 that feedback on learning was not an element that was conveyed by many children. Research has shown that formative feedback is essential to encourage deep learning (Higgins, Hartley, & Skelton, 2002). Therefore when designing and developing serious games other stakeholders including educational technologists or teachers may need to be consulted in the design phases to ensure crucial aspects are not overlooked. Alternatively more emphasis might need to be placed on clearly explaining to the children the essential educational theory (like feedback) which may be required for the game. This also links into the analysis within the 3rd space and ensuring that the dimensions within this space are clearly defined and represented.

Bhaba's concept of the 3rd space (Bhabha, 1984) from which Müller got his inspiration, identified the 5 categories:

- Overlap between two (or more) different regions of fields (inbetweenness)
- Questioning or challenging of assumptions
- Negotiations and (co-) creation
- Dialogue across and within differences (disciplines)
- Heterogeneity as the norm

Within the context of serious games these challenges are evident as the design process crosses the two paradigms of games and education that can result in conflict. There is also the relationship between the designers (in this instance the children) and the software developers, with a need to consult other stakeholders. This relationship is depicted in Figure 7 which represents a model of the 3rd space within the context of serious games.

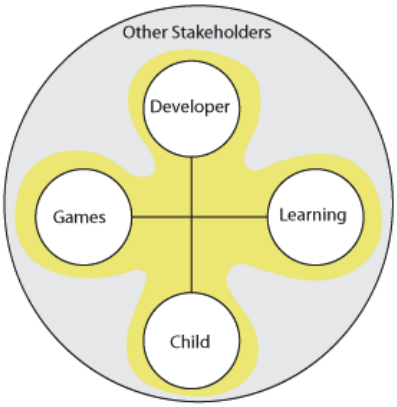

Figure 7. The five dimensions within serious games

The key challenge within this model is to establish a methodological approach to ensure a harmonious integration of ideas and theoretical concepts which results in an effective design process for serious games.

The space along the axes represents the 3rd space in which novel ideas are formulated but conflict and tensions can arise. There may also be external pressure from other stakeholders which can influence all the axes – as an example in the context of primary learning - a change in a national curriculum. Within the child - developer axis there was little conflict within our own study, this might have been as a result of the fact the technology was clearly explained to them, many of the children had experience of the technology and thus the majority of ideas generated were feasible.

There was more conflict along the game - learning axis. Children showed the capacity to regurgitate knowledge which is a lower cognitive skill as defined in Bloom's Taxonomy (Bloom, 1956), but showed little evidence of clear integration of learning, assessment and feedback within the overall game design. The majority of the designs were skewed to either the game or the learning with almost half the designs focusing on a linear narrative of how to wash hands as shown in Table 3 above.

7. Conclusions

The first version of the game was taken to rural Uganda to be field tested with children. The game was received very well by the children and all the children were very absorbed when watching the introductory animation clip, and they were very keen to then try out the game. In an evaluation study the children rated the game on its gaming elements and educational values (learning): e.g. most of the children who played with the game would like to play it again and they also expressed that they would like to take it home with them. When comparing this game with the Angry birds game the children opinioned that the hand-washing game was less 'stupid' than Angry birds – this suggests that they partially appreciated its serious nature.

Given that children in the UK were able to develop game concepts (as designers) and given that the children in Africa enjoyed the game so designed (as users) future work will explore the creation of dialogues across these two groups in the exploration of the third space. There may be conflicts and tensions on the culture differences, however it will be a very valuable process for children to learn about each other and deliver a truly meaning product.

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