 The definitive version was published in Proceedings of the 52nd ACM conference on Computers and people research , ISBN: 978-1-4503-2625-4, http://dx.doi.org/10.1145/2599990.2600008.

Great Expectations: What Do Children Expect From Their Technology?

Jessica Korte
Griffith University
170 Kessels Road
Nathan, Queensland, Australia
+61 7 3735 5191
jessica.korte@griffithuni.edu.au

Leigh Ellen Potter
Griffith University
170 Kessels Road
Nathan, Queensland, Australia
+61 7 3735 5191
l.potter@griffith.edu.au

Sue Nielsen
Griffith University
170 Kessels Road
Nathan, Queensland, Australia
+61 7 3735 5025
s.nielsen@griffith.edu.au

ABSTRACT
Children of the digital generation have expectations of technology that may or may not reflect the expectations of the adults around them. This paper explores the expectations of and attitudes towards technology of a group of young Deaf children while interacting with a computer game application. We found that the children expect seamless, intuitive behaviour from technology in part based on their existing experience with game platforms, mobile technology, and other computer games. In addition to high expectations of the technology, the children were highly adaptive to unfamiliar interfaces, tolerant of prototype deficiencies once they were familiar with the prototyping approach and could readily interact with new game elements. The challenge for developers is to create applications that harness the creativity of the digital generation and meet their high expectations. We suggest that involvement of children within the development approach will assist in meeting these goals.

Categories and Subject Descriptors
H.5.2 User Interfaces: [**Information Interfaces and Presentation**]: User Interfaces – *graphical user interfaces (GUI), prototyping, screen design, user centered design.*

General Terms
Design, Human Factors

Keywords
Child Computer Interaction; Attitude towards technology; Deaf Children; Deaf; Children

1. INTRODUCTION
Children expect an "interconnectedness of experience" - to be able to intuitively and immediately interact with the media that they use [2], whether that is by touching the pictures in a reading book, or by interacting with media elements using technology such as computers, tablets and smart phones. This technology is increasingly available to children as part of their everyday lives, and software applications are specifically developed for children from pre-school age through to adulthood.

While research has been conducted into how technology can be used to support children in a range of activities, much of this research comes from adult choices and approaches on behalf of children. The view of adults is frequently different from that of the child [22] as the child has differing expectations and desires [15]. This paper presents the experience of the child in their interactions with technology and software applications designed for children.

In an increasingly digitalized world, designing with and for children takes on new significance, as not only are these children current technology users but they are also potential future technology developers. Early exposure to technology has been shown to influence the level of intrinsic motivation that an individual has towards interacting with technology and the consideration of the Information Technology area as a career choice [21]. Game design and game play is suggested as a motivating factor for interest in computing and the production of technology [5]. A better understanding of children's expectations of technology may allow the development of approaches to encourage an interest in technology, and advance Information Technology as an attractive career choice.

This paper seeks to describe the way several young children interacted with a game-based technology application and their experience with that interaction and with the technology they used. In doing so we will explore the children's expectations of how the game would work based on their experience with the internet and mobile technologies.

We present a narrative discussing the experience and expectations of these children, and the observations that we noted during the experience. A narrative as it is used here is defined in its simplest terms as a "tale, story, recital of facts" [18], with our experience presented as such a story. Our observations represent 'lessons learned', which in this context is taken to mean "knowledge gained through experience, which if shared, would benefit the work of others" [1].

2. THE CHILD

The word 'child' can be applied to a range of ages, with many sub-categories possible. For the purpose of this paper, the focus will be on younger children under the age of twelve. This choice is a convenience choice made to match the focus of the author's larger research project, which seeks to assist young and very young children in learning signs in Australian Sign Language (Auslan).

The children who participated in this project are Deaf, and it is important to clarify the appropriate terminology for the Deaf community. Individuals who have some form of hearing loss may be described as 'deaf'. The capitalised 'Deaf' describes individuals who identify as belonging to the signing Deaf community and who communicate using Auslan. Deaf individuals may describe themselves as "Culturally Deaf." The term 'hard of hearing' is a broader term describing individuals with a hearing loss who usually communicate with speech [25]. This paper will follow the conventions of Deaf Australia and use the term ""deaf" when referring to all Deaf and hard of hearing groups at once."

3. THE TECHNOLOGY EXPERIENCE FOR THE CHILD

Children from developed nations are commonly described as the digital generation, or "digital natives" – the generation born into a digital world with access to networked, digital technologies [20]. With this label comes assumptions around children's competence with and attitudes towards technology [13]. A comparison of children's attitudes in 1999 and again in 2009 found that children are able to conceptualise both technology and the concept of computers from as young as six years old, and that they can create these ideas at a younger age now compared to 1999. In 2009 children were more likely to describe entertainment, communication and game based activities when describing technology, whereas in 1999 descriptions were related to the physical nature of the computer itself [19]. Children's conceptualisation of technology has moved to include a broad range of devices such as mobile phones in addition to a computer.

These conceptualisations may stem in part from the ubiquity of technology within the home. According to the Australian Bureau of Statistics, 79% of Australian households had access to the internet at home in the 2010-2011 period, with high income households reaching as high as 95%. Households with children under the age of fifteen were reported as more likely to have home internet access, with this group at 93%, and 90% of children aged five to fourteen had accessed the internet in the twelve months to April 2012. This percentage was lower for the five to eight year old group (79%) and higher for the twelve to fourteen year old group (98%). 29% of children owned a mobile phone, with percentages again increasing with age. 95% of households with children under fifteen have a personal computer [12].

Coupled with technology in the home is the global rise of technology in study environments. In Australia, government policy has focused on providing children with individual access to computers, with initiatives such as the Digital Education Revolution (DER). This initiative ran from 2008 until mid-2013, and aimed to give all students from grade 9 to grade 12 access to technology such as a laptop or PC. This would then support the development of an online national curriculum and the development of online and digital learning resources. It was reviewed in 2013 and "broadly regarded as a major success." [4].

Current technology initiatives involve the deployment of tablet computers to both primary and secondary school students. This is consistent with the Tablets for Schools initiative in the United Kingdom. In the United States, 43% of students and teachers are reported to use tablet technology in education, supported by the ConnectED program bringing broadband to schools.

Attitudes held by children towards technology do of course vary between populations. A study of children aged eleven to fourteen found that children from a lower socio economic background were more cautious towards computers than children from wealthier families [9]. However, they were also positive about the importance of technology, especially at younger ages [9, 16].

Studies of very young children's interaction with multimedia found that the children were enthusiastic and needed little encouragement to interact with the technology. Even at two years of age, these children were able to interact independently with a customised laptop and software [9]. This finding is supported in part by Mcknight and Fitton [17], who found that young children were able to comfortably use touch screen devices from the age of six, and were familiar with a range of on-screen gestures. They did find that younger children were more prone to unintentional screen touches, resulting in minor errors.

McKenny and Voogt [16] found similar positive attitudes in a group of four to seven year old children. These children stated that they were able to independently or with help complete a range of computer tasks, such as game play, drawing, and internet search, with proficiency increasing with age. The amount of computer use also increased with age. Children described their primary computer activity as playing games, with school related activities become more common as children progressed through school. This is consistent with the activities listed by the ABS Australian surveys [12].

A study of children's interactions with tablet computers found that the children were motivated and enthusiastic about the technology. They were comfortable in exploring the application on the tablet and in making mistakes, persisting with their interaction regardless [3]. One child involved in the study observed: "Sometimes the computer doesn't hear you.… I just keep trying and trying until it [the computer] gets it right." (p. 91). This is in contrast to the reactions shown by many adults, who tend to blame themselves for errors.

4. DEVELOPING TECHNOLOGIES FOR DEAF CHILDREN AROUND THE WORLD

There has been very little development of technologies for Deaf children learning sign language in Australia. Some multimedia tools have been created in recent years for hearing and deaf children [8], and a number of tools exist for adult and/or hearing audiences; but nothing until the Seek and Sign project has focused on creating technologies specifically for Deaf children.

International efforts also seem rather sparse. American Sign Language (ASL) has fared the best, with a number of research projects being completed over the last decade. Key examples are CopyCat [10, 14], the iSign Bear [11] and PlayWare [26]. All three of these programs present non-standard technology interfaces. The iSign Bear and PlayWare are not intended to be treated as technological artefacts, but rather to integrate into the already existing physical world of the child. CopyCat has an interface which is controlled by sign-like gestures. Each of these

approaches has benefits, and potential to help young Deaf children acquiring a sign language. However, it is less helpful for this investigation of children's use of "standard" technologies – technologies and programs which are designed for children, but still rely on their skills and knowledge with existing hardware interfaces.

5. OBSERVING CHILDREN'S EXPECTATIONS OF INTERACTION

In the next two sections, we will describe the Sign My World case study. Sign My World is an application intended to aid young Deaf children in learning signs from Auslan. We included members of our target audience, preliterate deaf children and children in their early years of schooling, in the development of the Sign My World application. This was in order to realistically address their expectations. To do this, we took a child-as-informant approach to requirements elicitation, as described within the Cooperative Inquiry approach [6, 24]. As a preliminary study we conducted a series of prototyping sessions with a small number of Deaf children from the target audience, recording their comments and observations about their behaviour. These were used to identify new requirements and changes to existing requirements, which were used in turn to modify the prototype for the next testing session. Discussion of the results of the prototyping sessions, with particular focus on the children's interface expectations, is in the next section.

Eight prototyping sessions were conducted with three participants, who we will call "Pat", "Roger" and "Richard", where the children interacted with an evolving prototype of the application. All three of the participants were familiar with computers, both desktop and laptop, and iPads, to which they had access at home and school. Roger's parents also reported that he played console games.

Pat was a profoundly deaf seven year old boy who had had a working cochlear implant for the preceding two years. Pat attended a Special Education Program; however sessions with Pat took place at his home. Roger and Richard were two hearing-impaired boys who were also aged seven. Both boys wore hearing aids and were learning vocalised English through a Special Education Program attached to an Education Queensland school. All three of the boys were learning Auslan.

Pat's mother and grandmother were present for his prototyping session. His grandmother acted as Auslan interpreter for the application developer for his session. The sessions with Roger and Richard took place within the dedicated Special Education Program building at their school. Roger and Richard sat on adjacent edges of a small, square table, with an Auslan interpreter from the school sitting at one of the opposite sides of the table. This afforded the interpreter a place where she could see and be seen by Roger and Richard. The application developer sat beside the participants, so that their interaction with the prototype was visible. All eight of the sessions were conducted with the prototype presented to the children on a laptop computer.

The prototype was built in Adobe Flash, as this program allowed our requirements elicitor to create dynamic, interactive prototypes quickly.

The initial prototype used in testing consisted of a single virtual area which users could explore, as shown in figure 1. Clicking on animated item buttons would trigger a video flash card, displaying the item which had been clicked, the English word for the item, and an Auslan sign video for the item, as shown in figure 2. When the flash card first opened, the image of the item clicked was displayed in the centre of the screen for two seconds. Then it would resize and relocate to the top of the screen, and an Auslan sign video would be displayed at the centre of the screen. The video could be replayed after it had finished, by clicking the play button. Clicking on the image icon would display the image in the centre of the screen at full size once more.

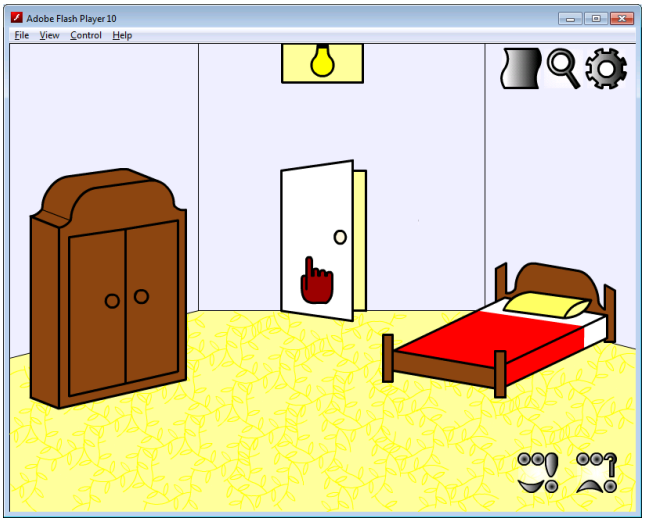

Figure 1. Prototype initial screen. © Seek and Sign

Figure 2. Video flash card. © Seek and Sign

During every prototype testing session, the children would interact with a new version of the prototype. In most sessions, this was the sole tool used for information gathering. However, in Session 2 with Richard and Roger, a small paper prototyping activity was also conducted. This will be described in more detail below.

6. LIMITATIONS

It is acknowledged that these sessions were conducted with only three children. The purpose of the sessions was to prototype an initial application for the Sign My World game, and further development is currently ongoing. Subsequent sessions with

more children will be required, and the story told here is specific to the participants in this prototyping round. We will describe the children's interaction with the technology used in the prototyping sessions and with the application in narrative form, and our aim is to generate insight that will influence future prototyping rounds.

7. SIGN MY WORLD PROTOTYPING SESSION OBSERVATIONS

7.1 Descriptive Survey

At the commencement of the study, parents of participants were asked to complete a descriptive questionnaire which provided details about participants' demographic, computer access, and demonstrated recreational preferences. Two of our participants' parents responded, and a summary of their responses are shown in Table 1.

Table 1. Questionnaire responses.

Question	Roger	Richard
Age	7	7
Gender	M	M
Languages	English	English
Home computer?	Yes	Yes
Home internet?	Yes	Yes
Supervised home computer / internet time (hours/week)	1-2	2-3
Unsupervised home computer / internet time (hours/week)	0	0
Smartphone/tablet device?	No	Yes, iPad
Conditions of smartphone / tablet use?	-	No conditions – most apps are learning games or drawing/photography
Supervised smartphone / tablet time (hours/week)	-	3-4
Unsupervised smartphone / tablet time (hours/week)	-	2
Technology use at school?	Unknown	Unknown
Computer activities?	Artwork, learning games, photography, music	Artwork, learning games, videos, recreational games
Use of non-computer gaming platforms?	Yes	Yes
Choice of games	Puzzles, sport, Lego, Wii, PlayStation	Puzzles, adventure

7.2 Sessions with Pat

The pilot session was conducted with Pat. He was presented with the initial prototype on a laptop computer. It had been assumed that, due to his reported familiarity with technology, presenting the prototype on a laptop would not present a problem. However, he had some difficulties, because he had not encountered a laptop touch pad before. He had difficulty controlling the pointer, and using the left- and right-click, as the button did not have a clear separator between the two. After a short demonstration, he adapted quickly to using it, however general assumptions often attributed to 'digital natives' were incorrect in Pat's case.

Pat quickly worked out that the animated item buttons in the prototype could be clicked on. He ignored the smaller, static 'tutorial' button that had been included (visible in Figure 1).

The first time he viewed a video flash card -- which greys out the area of the interface not covered by the video -- and tried to exit, he was surprised to see that it did not work as he expected. There was a 'back' button, shown in figure 2; he was trying to return to the 'room' by clicking on the greyed-out area. He became rather frustrated that the interface did not work as he expected it to. This navigation was simplified in future versions of the prototype in response to his frustration.

When Pat had explored the entire prototype, roughly 10 minutes into the session, he began exploring the laptop desktop and looking for other programs. It was at this point that the session was ended.

At the beginning of the session, Pat was told to play with the prototype and share his thoughts about it, as per the procedure of gestural think-aloud protocol [23]. He was not prompted again throughout the session, and did not provide many utterances. Therefore, the majority of data gathered from this session came from researcher observations of his reactions.

From this first session, we observed that assumptions regarding technology familiarity needed to be confirmed with the children prior to introducing them to the prototype. Pat expected to be able to click on a button, just as he could in other applications. He was frustrated when the application did not behave as he expected, based on his experience with other games. It appears that he expected a degree of consistency in his interaction with the technology.

7.3 Sessions with Richard and Roger

Using the lessons learned from the pilot session, the laptop used for testing sessions with Richard and Roger had the desktop icons and taskbar hidden so that the boys were not distracted. Richard and Roger were also supplied with a plug-in mouse, which was familiar from their existing experience with laptops at school. In later sessions, it would be revealed that Roger was also familiar with the touch pad.

Richard and Roger attended all but one session together – the exception being when Roger missed a day of school due to illness – and would take turns controlling the prototype. They would often offer input or suggestions to one another on what to do while using the other was controlling the prototype.

At the start of the sessions, Richard and Roger were instructed in English and Auslan to play with the prototype and to vocalise or sign what they thought of it. This is in line with usability testing think-aloud and gestural think-aloud protocols [23], and matched

the introduction Pat was given in the pilot session. Unlike the pilot session, however, Richard and Roger were prompted throughout the sessions to share their thoughts when their reactions were particularly emotional.

7.3.1 Session One

Initially, neither child clicked on any of the animated buttons until prompted by the designer, although they were delighted by the animations themselves. This might have been due to nervousness about the unfamiliar situation they found themselves in.

Richard had more experience using computers than Roger did, and began to use the interface more quickly. He showed Roger how to replay videos and attempted to demonstrate button hit zones when Roger had trouble clicking directly on the area he wanted, again challenging the 'digital native' assumptions.

When prompted for thoughts and suggestions at the end of the session, Roger suggested that the prototype should be expanded to include a kitchen, and listed some signs he would like to see there. When asked for ideas on how navigation between different rooms could be introduced, Roger drew on his real-world experiences rather than his knowledge of technology, because he said he would "walk downstairs".

Based on these early observations, it appeared that pre-existing familiarity with technology was an influence on the children's interaction with the laptops and with this application. The boys appeared happy to interact with the prototype, and to blend their understanding of games and technology with real-world experience, as shown in the case of Roger's suggestion of the kitchen.

7.3.2 Session Two

In session two, Roger and Richard quickly identified the only change made to the beginning interface between sessions -- a new button which allowed them to navigate between rooms, as shown in Figure 3. This easy identification of visual change may be specific to these boys, as Deaf children rely largely on visual-spatial cognitive perception and processing [7]. The boys readily identified any visual changes to the application, no matter how minor. Further comparison with hearing children would need to be undertaken to compare this skill.

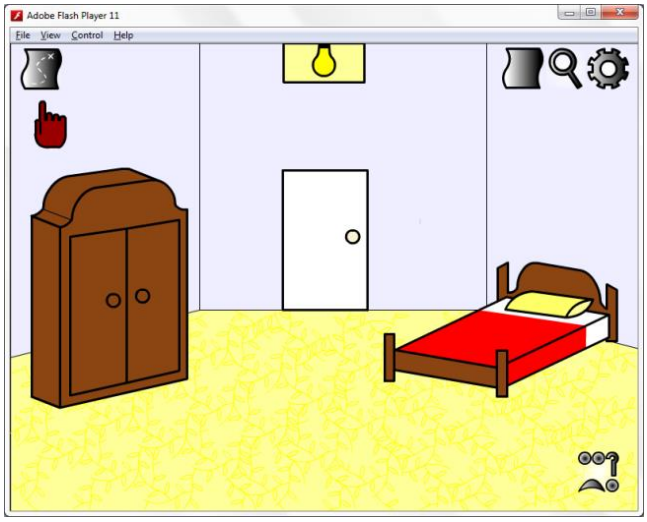

Figure 3. Updated prototype initial screen. © Seek and Sign

The new button led to a map screen, shown in Figure 4. The participants' behaviour on viewing this screen demonstrated their pre-existing familiarity with technology and the effect this had on their expectations once more. Each room was represented by a white parallelogram with a symbol representing the room on it. The boys were surprised when the parallelogram was not part of the clickable area. They were also surprised that the roof, which had a similar appearance to the item buttons in the bedroom, was not clickable. Both of these issues were addressed in future prototypes.

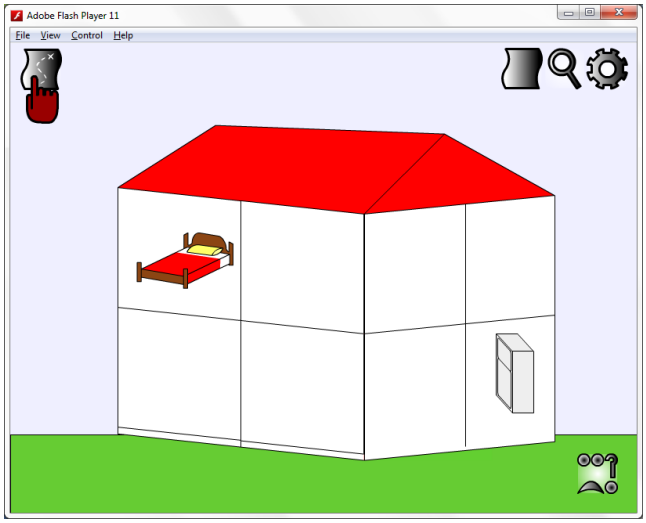

Figure 4. New 'map' screen. © Seek and Sign

This prototype also introduced a new room, the Kitchen, as per Roger's suggestion in the previous session. His suggestion, which included a number of food items, had not been completely implemented in code. Instead, the participants were presented with a paper prototype of how food items might be found "inside" objects such as the fridge. Once the boys approved of the paper prototype, it was implemented, as shown in Figure 5, and was present in the prototype tested in Session Three.

Figure 5. Items "in" the fridge are accessed by scrolling through a list. © Seek and Sign

7.3.3 *Session Three*

During session three, Richard revealed that he was familiar with how laptop touchpads worked by trying to control the mouse while it was Roger's turn. Roger was interacting with the game using the mouse, and Richard stepped in and started using the touchpad to try to control the interaction.

7.3.4 *Session Four*

During session four, the participants were mostly understanding about an interface bug, especially as it was one that was easily fixed. They also demonstrated that they understood the concept of scrolling, by being able to find all the items "in" the fridge, as shown in figure 5.

7.3.5 *Session Five*

In session five, Richard decided he would rather use the laptop touch pad than the mouse. He had no problems in using it. Roger, on the other hand, experienced some frustration. His cursor movements were unsteady, and he had some difficulty focusing on the items he wanted to click on. Despite this, he did not want to use the plug-in mouse when it was offered.

7.3.6 *Session Six*

In session six, both participants demonstrated once again that they expect consistency from the interface. They were dismayed to see that some new item buttons were not animated, as the previous ones had been.

Both participants seemed to have realised how the requirement elicitation sessions worked by session seven, and were excited to realise their input really was being used to change the prototype. They were keen to give suggestions during the final two sessions, and both listed a large number of things they would like to see included in the game. They became active participants in the process and were enthusiastic in their participation.

They had also realised that interface bugs were fixable, and when they occurred calmly asked for them to be fixed.

At one point, Roger tried to replay a video by clicking on the video itself. Due to the way Adobe Flash treats videos, this was registered as a click on the background, and the video flash card was closed. He was surprised and annoyed by that, and clicked on the triggering item again to access the same video flash card.

7.3.7 *Session Seven*

During the final session, the participants revealed that they were aware of customisable avatars in other games and programs, and when asked, said they would enjoy something similar in Sign My World. The prototype for this session had a partial implementation of this, as shown in figure 6. The way the avatar creation was set up to work was that the user should be able to select a part of the face to see the sign for it, in a predetermined part of the screen, and then they would be able to make changes to it. This did not match the way Richard expected it to work. Because there was a loading bar where the video would appear, and the changing arrows did not work (because he had not selected a body part), he declared it to be "not working" and returned to the main part of the house. After the way it worked was explained to him, he tried it again, and quickly got it working. Roger had a little more trouble during his turn, as he kept attempting to double-click on the arrows, and got frustrated when it changed twice.

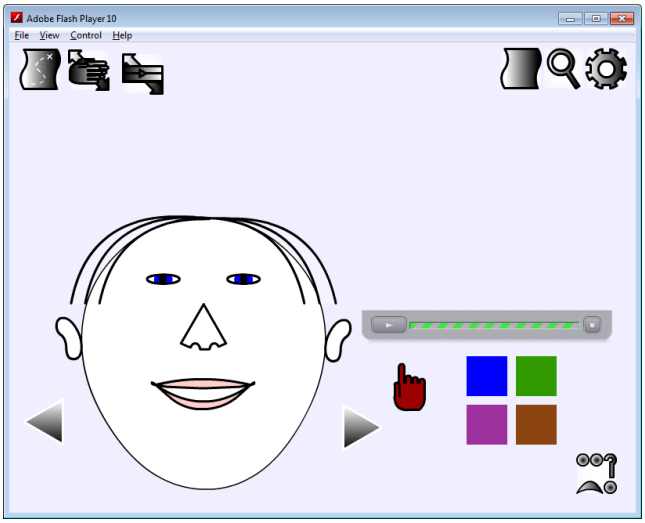

Figure 6. Avatar personalisation screen. © Seek and Sign

7.3.8 *General Observations*

Throughout the sessions, none of the participants clicked on the symbol icon for the sign they were viewing; nor did they seem to realise when an extra set of 'verb' buttons were unlocked and appeared on the 'door' video flash card (see figure 7), as these remained unclicked.

Figure 7. Video flash card showing verb buttons. © Seek and Sign

Further work would need to be undertaken to ascertain the reasons behind this lack of interaction with the icons, and whether this stemmed from a lack of familiarity or from another reason.

8. CONCLUSION

In this paper we aimed to present the experience of several children with a game based technology application, and to explore their expectations of and attitude towards their interaction with the technology that they used.

Our participants' interactions with Sign My World demonstrated in-depth knowledge of technological norms. Their interactions with the interface seem to suggest an expectation of seamless, intuitive behaviour from technology. Some of these expectations seem to have been shaped by previous exposure to computer games, smart phone apps and online content. This presents a

challenge for developers for children - how can you ensure that an implementation which seems logical to you will be truly intuitive to your users? The answer would seem to be to involve members of your target audience in the design throughout the design of the application. In the development of the Sign My World prototype, participant feedback and reactions were key in streamlining the interface, and ensuring user expectations were met. It is possible that this involvement may also encourage a further interest in Information Technology, and the enthusiasm and level of participation by our participants is a positive indicator.

Some observations of the children using technology challenge the assumptions associated with 'digital natives'. Balancing this, it was also noticeable that, in addition to their high expectations, our participants were highly adaptable when it came to encountering software or hardware interfaces they were unfamiliar with, once the underlying logic had been explained or demonstrated. The inclusion of short, visual, interface tutorials could help to ensure that users are not distracted from content by frustration with the interface; although of course, the best interface is one that needs no explanation.

The children in the prototyping sessions encountered some challenges with mouse control and this is consistent with experiences described by Ellis and Blashki [9]. Sign My World is currently being redeveloped for deployment to tablet devices. This will enable a comparison between the child's game experience using a mouse and their experience using touch.

9. REFERENCES

[1] Abecker, A. and van Elst, L. 2009. Ontologies for Knowledge Management. *Handbook on Ontologies*. S. Staab and R. Studer, eds. Springer. 713–734.

[2] Bearne, E. 2003. Rethinking Literacy: Communication, Representation and Text. *Literacy*. 37, 3 (2003), 98–103.

[3] Couse, L.J. and Chen, D.W. 2010. A Tablet Computer for Young Children? Exploring Its Viability for Early Childhood Education. *Journal of Research on Technology in Education*. 43, 1 (2010), 75–98.

[4] danolopartners 2013. *DER Mid-Program Review: Assessing Progress of the DER and Potential Future Directions – Final Report*.

[5] Denner, J. 2007. The Girls Creating Games Program: An Innovative Approach to Integrating Technology into Middle School Jill Denner. *Meridian: A Middle School Computer Technologies Journal*. 10, 1 (2007).

[6] Druin, A. 2002. The role of children in the design of new technology. *Behaviour and Information Technology*. 21, 1 (2002), 1–25.

[7] Ebrahim, F. 2006. Comparing Creative Thinking Abilities and Reasoning Ability of Deaf and Hearing Children. *Roeper Review*. 28, 3 (2006), 140.

[8] Ellis, K. and Blashki, K. 2007. The Digital Playground: Kindergarten Children Learning Sign Language Through Multimedia. *Education*. 15, (2007).

[9] Ellis, K. and Blashki, K. 2004. Toddler Techies: A Study of Young Children's Interaction with Computers. *Information technology in childhood education annual*. 1, (2004), 77–96.

[10] Henderson, V., Lee, S., Brashear, H., Hamilton, H., Starner, T. and Hamilton, S. 2005. Development of an American sign language game for deaf children. *Proceedings of IDC 2005* (Jun. 2005), 70–79.

[11] Huang, K., Smith, J., Spreen, K. and Jones, M.F. 2008. Breaking the sound barrier: designing an interactive tool for language acquisition in preschool deaf children. *Proceedings of IDC 2008* (Sep. 2008), 210–216.

[12] Internet and Mobile Phones: 2012. *http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/4901.0Main Features7Apr 2012?opendocument&tabname=Summary&prodno=4901.0&issue=Apr 2012&num=&view=*. Accessed: 2013-10-29.

[13] Lebens, M., Graff, M. and Mayer, P. 2009. Access, Attitudes and the Digital Divide: Children's Attitudes Towards Computers in a Technology-Rich Environment. *Educational Media International*. 46, 3 (2009), 255–266.

[14] Lee, S., Henderson, V., Brashear, H., Starner, T., Hamilton, S. and Hamilton, H. 2005. User-centered development of a gesture-based American Sign Language game. *Instructional Technology and Education of the Deaf Symposium, Rochester, NY* (2005), 1–8.

[15] Markopoulos, P., Read, J.., MacFarlane, S. and Hoysniemi, J. 2008. *Evaluating Children's Interactive Products: Principles and Practices for Interaction Designers*. Morgan Kaufmann.

[16] McKenney, S. and Voogt, J. 2010. Technology and young children: How 4–7 year olds perceive their own use of computers. *Computers in Human Behavior*. 26, 4 (Jul. 2010), 656–664.

[17] Mcknight, L. and Fitton, D. 2010. Touch-screen Technology for Children : Giving the Right Instructions and Getting the Right Responses. *Proceedings of Interaction Design and Children* (Barcelona, Spain, Jun. 2010), 238–241.

[18] Myers, M.D. and Avison, D. 2002. *Qualitative Research in Information Systems*. Sage Publications.

[19] Oleson, K.E., Sims, V.K., Chin, M.G., Lum, H.. and Sinatra, A. 2010. Developmental Human Factors: Children's Mental Models of Computers. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*. 54, 19 (2010), 1450–1453.

[20] Palfrey, J. and Gasser, U. 2010. *Born Digital*. Basic Books.

[21] Potter, L.E., von Hellens, L. and Nielsen, S. 2009. Childhood Interest in IT and the Choice of IT as a Career: The Experiences of a Group of IT Professionals. *Proceedings of the special interest group on management information system's 47th annual conference on Computer personnel research* (Limerick, Ireland, 2009), 33–40.

[22] Rabiee, P., Sloper, P. and Beresford, B. 2005. Doing research with children and young people who do not use speech for communication. *Children & Society*. 19, 5 (Nov. 2005), 385–396.

[23] Roberts, V.L. and Fels, D.I. 2006. Methods for inclusion: Employing think aloud protocols in software usability studies with individuals who are deaf. *International Journal of Human-Computer Studies*. 64, 6 (2006), 489–501.

[24] Scaife, M. and Rogers, Y. 1999. Kids as Informants: Telling us what we didn't know or confirming what we knew already? *The Design of Children's Technology*. A. Druin, ed. Morgan Kaufmann. 28–50.

[25] Terminology: 2010. *http://www.deafau.org.au/info/terminology.php*. Accessed: 2013-10-29.

[26] Yarosh, S., Huang, K., Mosher, I. and Topping, M. 2008. Playware: augmenting natural play to teach sign language. *Proceedings of CHI 2008* (Apr. 2008), 3249–3254.