Proceedings of the e-Skills for Knowledge Production and Innovation Conference 2014

Cite as: Chimbo, B., & Gelderblom, H. (2014). Comparing young children and teenagers as partners in co-design of an educational technology solution. *Proceedings of the e-Skills for Knowledge Production and Innovation Conference 2014, Cape Town, South Africa,* 73-86. Retrieved from http://proceedings.e-skillsconference.org/2014/e-skills073-86Chimbo788.pdf

Comparing Young Children and Teenagers as Partners in Co-Design of an Educational Technology Solution

Bester Chimbo
University of South Africa, Pretoria, Gauteng, South Africa

chimbb@unisa.ac.za

Helene Gelderblom
University of Pretoria, Pretoria, Gauteng, South Africa

helene.gelderblom@up.ac.za

Abstract

This paper describes the design of a social media-based system aimed at providing after-school learning support to primary school children in South Africa. Through this system, teenage tutors will provide homework support to younger children who do not have access to such support. The design team consisted of six children aged nine and ten years, nine teenagers and two adults. During the design we aimed for as little adult interference as possible and rather allowed the teenagers to facilitate the sessions with the young design partners. Our idea was that combining teenagers and young children would yield richer results, helping us to overcome adult-child power relations and hence get more out of the young partners. We discuss and compare the design contributions made by the respective groups; we describe the difficulties and the positive outcomes when co-designing educational technology with children from two different age groups; and we make recommendations in this regard based on our experience. Results from the study showed that co-designing with partners from different age groups had both advantages and disadvantages related to age-specific preferences. However, if managed correctly, the variation in preferences could yield richer designs that are more successful on account of the diversity of design contributions.

Keywords: Participatory design, cooperative inquiry, educational technology, teenagers, young children.

Introduction

Reports in the literature on participatory design with children in South Africa are minimal in comparison to first world countries. Affordable computing options for homes and schools have led to children becoming the largest group of computer users in the world, including in some parts of Africa (Farrell & Isaacs, 2007; Madden et al., 2013; Winthrop & Smith, 2012). The use of mobile devices by children has also increased dramatically. Although there are still many areas in developing countries where poverty and lack of infrastructure prevent access to technology, many children in disadvantaged communities do have access to mobile technology (Mogotlane et al.,

2010) through cellular networks. Internet access in South Africa is unfortunately still expensive and mobile phones in rural communities are rarely used to access the Internet. With prices dropping and access spreading, there is a future in sight where most parts of South Africa will have access to affordable (or possibly even free) broadband access (Barnard & Joss, 2012).

Social media applications are widely used by children for social interaction and sometimes for learning-related interaction. These media provide a potential platform where children can provide each other with learning support (Nerantzi & Beckingham, 2014; Winthrop & Smith, 2012). This is already happening informally and formally. Dr Math is one successful example of a tutoring system where university students help high school children with homework through MXit (Butgereit, 2007). Working from the assumption that children's problems with reading and mathematics should be addressed as early as possible, we are developing a social media based tutoring system that will be suitable for children who are very early in their schooling careers, to receive assistance from teenagers.

Children are both cognitively and physically different from adults. The design and development of children's products is generally done by adults. So, developing products for children that are both usable and engaging is hindered by designers as it is impossible for an adult to perceive the product through the eyes of a child (Burton, 2006). It is therefore crucial to include children in the design process. Since our system will simultaneously be used by teenage tutors and young tutees, we included children from both groups in our design team.

In this paper we investigate the different roles that children of two different age groups play in co-designing educational technology. The questions we ask are:

1. How do the outcomes of the design process with young children and teenagers compare?
2. How does the design behaviour of young children and teenagers compare?

Participatory design (PD), aims to help the designers develop user interfaces by actively engaging the end users. Involving children as much as possible in the design process initiates and facilitates innovations and improvements to the final design that might not otherwise have been thought of by adult designers. The principles of PD are the most suitable for design projects involving children as "their creativity and enthusiasm thrive within a flexible structure, and educational techniques have long stressed the benefits of mutual learning" (Nesset & Large, 2004, p. 144).The success of the participatory design activities and the increase in recognition of children as an important computer user group, has led to the involvement of children in the PD process.

Participatory Design with Children

Participatory design, in its simplest form, can be described as actively involving the stakeholders (most probably the users) in the design process (Benton et al., 2012; Druin 2002). The participatory design process involves the use of, for example, brainstorming and low-tech prototyping tools to capture and demonstrate the ideas of the participants.

For more than a decade, the growing market for children's computing products and packages has compelled designers to involve children in PD to understand their issues and needs better (Druin, 2005). Cooperative inquiry (CI) has been developed as a technique to involve children in the design process (Druin, 2002). CI has its roots in a number of established fields, namely, cooperative design, participatory design and contextual inquiry. While these methodologies offer a good starting point for design, they need to be adapted to suit design teams that include children (Druin, 2002). CI aims to provide insights into that world in order to design the best products for children.

Burton (2006) states that "the world through the eyes of a child is a vastly different place to that of an adult and the only way to obtain this view is through the involvement of the children" (p.13). Children and adults have a different perspective of the world resulting in a difference in mental models. Burton believes that a good user interface helps the user develop the correct mental model that matches the conceptual model developed by the designers. To create a successful interface for children, an understanding of children's mental models and thinking must first be established. This can only be done through the involvement of children in the design.

Common activities in PD and in CI in particular, include observation of the users and prototyping activities. Prototyping in CI involves visualising ideas through low fidelity prototyping techniques (Druin, 2002). It helps children communicate what they are imagining. The nature of the activity and the environment within which it is done should support the children and allow them to participate effectively. Low fidelity paper prototyping (Snyder, 2003) is highly visual and uses basic, familiar tools to design with. Children will be comfortable with this because most of them will have had exposure to using basic art supplies. Low fidelity prototyping in CI is sometimes referred to as bags of stuff – a technique in which children and adults are supplied with big bags filled with an assortment of art supplies such as glue, clay, string, markers, cork, and scissors from which to build their models (Guha, Druin, & Fails, 2013).

The majority of existing research on CI focuses on pre-school and primary school children, mostly between the ages of 4 and 11, leaving a gap in the literature on PD with teenagers. Fitton, Read, and Horton (2013) view teenagers as having the potential to be the best evaluators of technologies. They ascribe this to how teenagers relate to clothing, technologies and social media in ways that put them in a unique position compared to adults.

No examples of participatory interaction design with children in South Africa could be identified in the literature. Since technology is generally being introduced as a vehicle for solutions to problems in developing countries, such as inadequate education, children are often affected by the introduction of technology in these contexts (Roy et al., 2014). They should therefore be involved in the design of such solutions.

South Africa: Education and Technology

The Quality of Education in South Africa

Mathematics and literacy are key areas of child development and foundation phase education in South Africa. The skills required in these two areas are fundamental requirements for learning. Low levels of numeracy and literacy impact negatively on educational attainment and employment prospects, resulting in economic costs that are borne by the whole community (Chriswick, Lee, & Miller, 2003). The quality of education in South Africa is disappointing (Van der Berg, 2011). Surveys show that the level of cognitive achievement of many South African children is alarmingly low in key learning areas such as reading, mathematics and science (Seekoe, 2010).

The situation with respect to low educational achievement in South Africa has reached crisis level (Feza-Piyose, 2012; Fleisch, 2008). The Annual National Assessment report (ANA, 2011) attributes the alarming drop-out rate in high schools and problems in performance at tertiary level to a failure to get the basics right in the first few years of a child's education. The pass rate has been between 46% and 47% (Feza-Piyose, 2012; Taylor, 2011). Over half of the pupils are performing at a level that indicates that they have clearly not achieved the competencies specified in the curriculum (Seekoei 2010). An assessment which included numeracy and literacy tests among foundation phase (grades 1 to 3) pupils attending government schools, showed that only 17% of the grade 3 pupils scored 50% and above in their numeracy assessment and 31% in their literacy assessment.

Several socio-economic factors lead to poor performance in literacy and numeracy. In South Africa, many young children are cared for at home by family members with low literacy levels who cannot provide the necessary support with homework and preparation for tests. Poverty also contributes to poor performance in schools. Poverty has devastating effects on children's life chances of children, and nowhere is this more strongly felt than in schooling (Mji & Makgato, 2006 Taylor, 2011). There is also a huge shortage of teachers, especially teachers who can provide mother-tongue education to children who have English as a second or even third language. These and many other problems need to be addressed.

The Growing use of Mobile Technology in South African Education Systems

The potential of mobile technology is huge and it has broken ground for enhancing knowledge sharing activities among learners in schools (Hussein & Nassuora, 2011). There are increasing numbers of institutions of higher education in South Africa offering courses using mobile technologies as an alternative teaching and learning tool. According to Hussein and Nassuora (2011), regardless of such interests in mobile technologies in education, there is lack of academic research on the use of these technologies as a tool to support young children with their work, in or out of their school setting using social networking platforms. It is important to establish how these technologies can be incorporated into school and home settings for educational purposes.

If older children from privileged communities could be motivated to provide after-school learning support to younger children who do not have academic support at home, this could, in a small way, make up for the problems mentioned previously. Previous research has established that it is possible to find South African teenagers who are willing to act as tutors using social networking platforms (Chimbo & Gelderblom, 2012), to assist in homework and test preparations to lower-grade learners. Some of these older learners with access to mobile or computer technology are spending much of their time socialising with tools such as Facebook, Twitter and YouTube. An opportunity exists whereby the pervasiveness of mobile technology can be exploited to help with solving some of the problems in foundation-phase education in a developing-world learning context.

In our social media-based, cross-age tutoring system, teenagers would provide homework support to young children from disadvantaged communities. Young children who come from well-to-do homes usually have parents assisting them with their homework. In South Africa, many young children are cared for at home by siblings or family members with low literacy levels who cannot provide the necessary support with homework and preparation for tests. Having able children in higher grades helping those in lower grades would go a long way in bridging the support gap.

In designing our solution, we worked with teenagers from privileged schools in South Africa and young grade 3 and 4 children from a disadvantaged community.

Methodology

Overall Design Plan

The intended outcome of the design process is a social media based system that allows young children to request and receive online homework support from teenagers, without being exposed to any threats to their well-being. Our primary point of departure was that the application should as far as possible be designed by the end users – in this case, young children from disadvantaged communities and teenagers from privileged communities. Our plan was as follows:

1. Identify a community of underprivileged children where there is a need for homework support and where we would find young design partners.
2. Recruit teenage volunteers from privileged communities to join the design team.
3. For one month, take the teenagers to the children's home to provide face-to-face homework support to the young partners to immerse them in the design context.
4. Conduct CI sessions with the teenage partners and with the young partners, where they provide input into the design of the proposed system.
5. Analyse the design data from the design sessions, build a prototype and return to partners for feedback and refinement.
6. Develop the solution, implement it in a pilot environment, test, refine, test, refine and finally deploy the resulting system more widely.

In this paper we focus on steps 3, 4 and partly 5.

Participants

The community of underprivileged children that we identified as appropriate for the design phase of this project is a privately run children's home that has a branch in Pretoria, South Africa. The children in this home have mostly been placed there by the court of law, which means that many of them have been exposed to abuse or neglect. They attend public schools in Pretoria, and although they receive excellent care in the home, there is a need for individual after school homework support. With the help of the staff we selected 6 children in grade 3 or 4 (i.e. aged 9 or 10) as part of our design team – three boys and three girls. All of these children's home language is Afrikaans. They do all understand English well, but only two were willing to communicate in English.

Both researchers have children in public high schools in privileged areas of Pretoria, so nine teenage participants were recruited by word of mouth. They are between the ages of 14 and 17 (in grade 9 or 10) and are all female. Four of them speak English as their home language while the others speak Afrikaans. Two of the English-speaking teenagers do not speak or understand Afrikaans but all the Afrikaans-speaking teenagers are fluent in English.

The language barriers were overcome by the correct pairing of the tutors and the tutees. Since one of the researchers does not understand Afrikaans, the second researcher acted as translator when necessary.

Data Collection

The data collected during this design project consisted of:

- Audio recorded individual feedback on face-to-face tutoring sessions, transcribed and translated into English by one of the researchers.
- Physical paper prototypes created by the teenage designers in groups.
- Physical paper prototypes created by the grade 3 and 4 designers in groups.
- Video recordings of the presentation of the designs produced by the teenagers (all these presentations were done in English) and audio recordings of the presentations by the younger designers.
- "Big ideas" recorded by the researchers while the groups of teenagers and young children presented their designs respectively (those presented in Afrikaans were translated into English by one of the researchers).

Below we provide a detailed description of how this data was collected.

Part 1: Face-to-face sessions

The first part of the data collection took place during the month of face-to-face tutoring sessions (step 4). For four weeks in September 2013, the researchers took turns to take tutors to the children's home once or twice a week, depending on the availability of the teenagers. The number of teenagers that attended these sessions varied from one to five. This meant they were sometimes paired one-to-one, sometimes two-to-one, and sometimes one tutor would work with two groups of three tutees during one visit. During the sessions, the tutors would help the young children with their homework and test preparation. From the outset the researchers interfered as little as possible and allowed the teenagers to decide who to tutor, how many to work with at a time, what to cover in a session and how to go about it. At the end of each session, both the tutors and the tutees shared their experiences for the day through individual audio-recordings made either on digital audio recorders (provided by the researchers) or on mobile phones. These recordings were collected and later transcribed to form part of the data set to be used as input into the design.

Part 2: Participatory design sessions

The second part of the data collection involved participatory design sessions with the children. These took place in October 2013 at our university and at the children's home respectively. We decided to conduct separate sessions with the two groups. The tutors had one three-hour design session whilst tutees had two 90 minute sessions on separate days. In the tutors' session the researchers acted as facilitators, while the tutee design sessions were facilitated by some of the teenagers.

Tutors were divided into groups of three and asked to design and build/draw paper prototypes. We had prepared "bags of stuff" that included large sheets of paper, glue, sticky notes, stickers, colour pens, and more. Tutors were to reflect on their face-to-face tutoring experience and then translate those ideas into designing a system that could incorporate features of familiar social media (e.g. Skype, FaceBook and Twitter) but also completely new and innovative ideas. We used a combination of Muller's PICTIVE approach (Muller, 1991) and paper prototyping (Snyder, 2003). The groups worked for about 45 minutes on their designs. The tutors, though in groups, decided each to put their own personal ideas down first then collate their ideas within the group. Past participatory design research confirms this approach to be successful – the participants must believe their ideas are important (Burton, 2006). Figure 1 shows the three groups at work.

After combining their ideas, each group presented their design. Following Guha, et al. (2013), throughout these presentations one of the researchers wrote all the "big ideas" that emerged on a white board (see Figure 2). These became part of the data set.

Figure 1: Teenagers brainstorming in groups

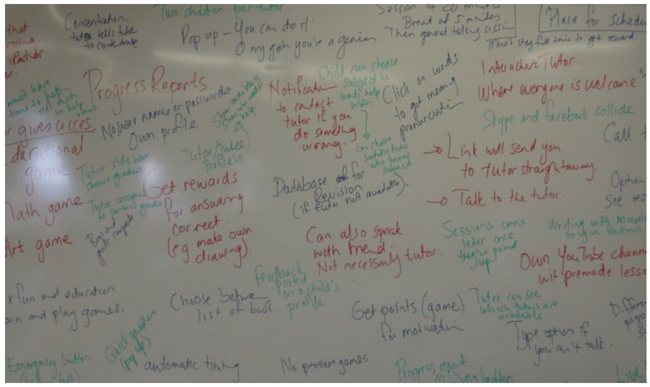


Figure 2: Big ideas recorded during teenagers' presentations

Figure 3: One group presenting their design

Figure 3 shows a group presenting their design and Figure 4 is another example of a teenage group's design.

Figure 4: A design prototype from a teenager group

As there was no restriction in our ethical clearance prohibiting us from using video recordings of the teenage participants, they were video-recorded whilst doing their presentations.

The tutees had their first session two weeks later so that some of the teenagers could help with facilitation. Four teenagers participated in the design sessions with the tutees which took place at the children's home. The tutees have had limited exposure to technology, therefore the first session of 90 minutes was spent on familiarising them with the design content (i.e. mobile technology, tutoring and social media) as well as with the general concept of design. The children

“Skyped” individually with a research partner in the United States to convey the idea that distance is not a problem in communication and that you can have face-to-face interaction with someone who lives far away. We then let them build an obstacle course using the adult researchers and the teenagers as the building blocks (or obstacles). They had to guide a blindfolded partner through the obstacle course. The obstacle course activity was borrowed from the University of Maryland’s Kidsteam design team. The objective is to give the children exposure to the act of design while simultaneously breaking down the power relations between the different generations in the team. We were very successful on both counts, afterwards reflecting as a group on the overall design idea in preparation for the actual design session.

We started the second 90 minute design session at the home with a “question-of-the-day” (also borrowed from Kidsteam practice) where each participant received a chance to answer the question “What is meant by thinking out-of-the-box?” Their answers demonstrated that they understood the concept well with one tutee giving the definition “it is when you think of things that you never even knew you knew about”. In the design exercise that followed, the tutees were teamed up either one teenager with one child or one teenager with two children. They were provided with the same “bags of stuff” that we used in the teenage session before and created paper prototypes.

The teenage facilitators were briefed beforehand to allow as much of the design ideas as possible to come from the younger partners. Through the activities of the first tutee design session it was made clear to the tutees that the process was informal and safe, and that they should feel free to air their views. After the session, the tutees reported back on their designs (e.g., Figure 5), and their “big ideas” were collected on paper by the researchers. The presentations were audio recorded only since our ethical clearance did not allow us to video record the young tutees.

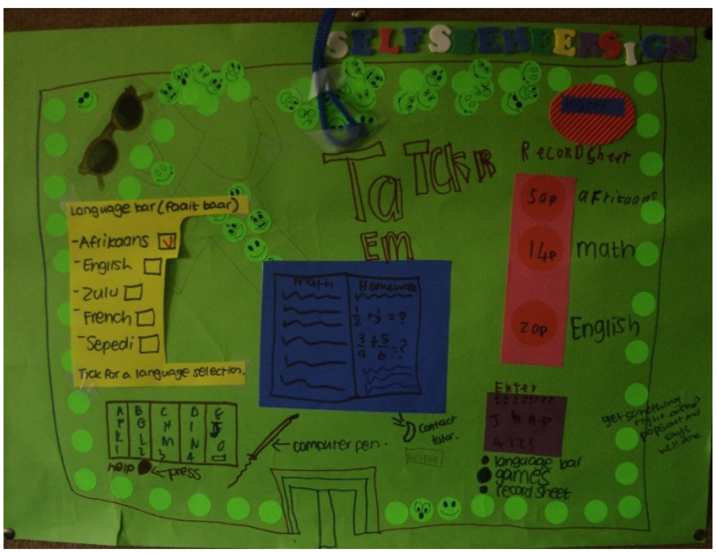


Figure 5: A design prototype from the tutees

Data Analysis and Results

All data was analysed qualitatively. Through cycles of comparative analysis of transcripts of audio recordings; video recordings of presentations; recorded big ideas; and the physical attributes of the prototypes, we searched for elements that could potentially provide input into the design of the intended tutoring application. We paid special attention to the similarities and differences in the results of PD with the teenage partners and the younger designers.

Results from the Audio Recordings

The audio recordings yielded little in terms of design suggestions. The following design ideas could be extracted from the teenagers' audio feedback:

- Tutoring should be one-on-one rather than one tutor working with more than one child at the same time.
- One should have other activities ready in case the tutees do not have specific homework or test preparation to do (e.g. teaching them French words or letting them read out loud).
- If the tutees need to be paired up they need to be friends because it would be difficult to work with two or more who do not get along.

The tutees' recordings demonstrated overwhelming appreciation for the visits and the tutoring that they received. Their stories provided clear evidence that there was a great need for homework support and that getting this from teenagers would be very well received.

The teenagers were much more comfortable recording themselves than the tutees. It was clearly a novelty for the latter and they were reluctant to express opinions about the tutoring situation, other than expressing their love and appreciation.

Results from the Design Sessions

Seven themes emerged during analysis of the designs produced during the design sessions, namely High-level interface design; Communication mechanisms; Additional features and functionality; Rewards and motivation; Monitoring and evaluating tutee progress; Social media elements; and Psychological design issues.

Comparing the design ideas of teenagers and young children

The following results provide an answer to the first research question: How do the outcomes of the design process with young children and teenagers compare?

The following similarities and differences were noted between the design ideas produced by teenagers and young children, respectively:

Differences. Teenagers distinguished between a tutor view and a tutee view, while the young partners only designed a single view. Teenagers had many ideas and could describe the full functionality of their design. Young children had few ideas and none of them could give a coherent description of how the interaction would proceed.

Young children were more focused on decorative elements that users could add themselves, while this did not come up in the teenage designs. Two of the three groups of young partners mentioned the need to choose which language they wanted to communicate in, while this did not come up in the teenage designs.

Teenagers thought about practical issues such as their own time constraints.

Rewards suggested by teenagers were tangible in the sense that they would give the tutee access to some actual fun activities; the rewards suggested by tutees were symbolic rather than tangible (i.e. a flower or a chocolate that should appear on screen).

Both groups wanted a way for tutors and tutees to write on screen, the young designers suggested a "computer pen" and the teenagers suggested standard input devices (e.g. a mouse).

Teenagers put a lot of emphasis on recording the tutees' progress and tailoring the interaction according to that. The young children showed a clear need for their own identity to be visible on their designs.

Similarities. Neither group just wanted a Skype-like interface where they could talk synchronously. Both groups requested much more – access to games, progress reports, fun rewards, et cetera. Both groups saw the need for a login screen and password. Both thought of synchronous as well as asynchronous uses of the system and they all regarded access to games as essential. They also agreed that there should be some choice with respect to who the tutor and tutee would work with.

Comparing the design behaviour of teenagers and young children

Considering the second sub-question (How does the design behaviour of young children and teenagers compare?) we found the following:

Aesthetics vs. functionality. Our young partners placed more emphasis on decorative design, while teenagers preferred detailed designs that emphasized textual content (although there was attention to the aesthetics). The young designers were interested to see how they could use the materials provided on their design prototype without necessarily connecting it to the specific functionality of the tutoring system. The teenagers showed a combination of focus on aesthetics and functionality, with some taking it upon themselves to determine which features should be included and others putting this together using the materials given. In general, the teenage designs were more functional and the young designs more decorative.

Creativity. Although both groups wanted a way for tutors and tutees to write on screen, the young designers were more creative in this by suggesting a "computer pen" as opposed to the teenagers' suggestion that writing could happen with standard input devices. Again, the younger designers were thinking out of the box, not afraid to try out new ideas, which would contribute to the innovativeness of the resulting designs. Further evidence that young designers found it easier to stray from what was practical was their suggestion for rewards in the form of symbolic gifts (e.g. an image of a flower or a chocolate that appears on screen).

The young designers asked for an interface that could be tailored according to their likes (e.g. placing their own pictures on it.).

Attitude towards incentives. The research shows that ideas for reward systems differ by age group. This finding will help designers to include appropriate incentive schemes based on the target age group for their designs. Related to incentive schemes is an understanding of what motivates different age groups to apply themselves at the highest level in any endeavour. While the teenagers suggested tangible rewards, such as the chance to play a game, the young children's ideas showed that they expected much simpler rewards (e.g. a symbolic chocolate).

Participation in groups. There were clear differences in the children's ability to work well in their small design groups. The teenagers were assigned to their groups by the researchers and accepted this readily. All three teenage groups worked together effectively and it was clear from their presentations that they all played equal parts in their respective designs. All group members of each of the groups contributed in the presentation.

The young groups struggled more and from reflections with the teenage facilitators afterwards it became clear that there was conflict between the young designers in both the groups that had more than one young member. These two groups did, however, produce more elaborate and useful designs than the group that consisted only of one young designer and one teenager. The boy in the latter group was very adamant that he did not want to work with any children and only with one specific teenager, which we conceded to. The presentations made by the young designers were also not as successful as those of the teenagers. In one group, the two children competed for speaking turns. The boy who designed alone with the teenager refused to present his design. The third group was successful in explaining their ideas, with some help from the teenage facilitator.

Conclusions

Creativity inherent in young children's thinking yielded designs of user interfaces that were rich in decorative elements and graphical content as also noted by Nesset & Large (2004). Teenagers emphasized textual content elements in their designs, as opposed to decorative ones. Working with both groups showed that "children" cannot be regarded as a homogenous user group and that when a system is to be used by children from different age groups both groups must be accommodated in the design. Had we only designed with teenagers, we might have ended up with a system that looks good in terms of functionality, but lacked the decorative aspects that would attract younger users. On the other hand, had we only designed with young children we might have ended up with a decorative, aesthetically adaptable interface but with (possibly unsuitable) functionality determined by adult designers.

Teenagers displayed different attitudes towards incentives than what was observed with younger children, which means the reward system used in an application aimed at more than one age group should be considered very carefully and evaluated with the various user groups. In this design case, we might have designed an intricate reward scheme that involved scoring and access to games, where a mere electronic flower could have sufficed.

In agreement with Little et al. (2013) we found that co-designing with designers from different age groups has its challenges – the respective age groups will emphasize their own design preferences. However, if managed well, the diversity of preferences from the different age groups should result in designs that are richer on account of the diversity of design preferences of the different age groups.

Involving teenagers as facilitators in the design sessions with the young designers proved very successful. This was a key motivating factor in getting the young partners committed to the design task. Important in the success here was the fact the teenagers had their own design session prior to their facilitation role, and thus had a clear idea of how to proceed during the sessions with the young children.

Difficulties Encountered During Design

Because of the various extra-mural activities of the tutors and their different schedules at school, it was difficult to find suitable times to bring all of them together. So, during the preparation for design phases (i.e. the face-to-face tutoring sessions) we relied on their availability to determine who went to the children's home. Sometimes only one tutor was available and had to split her tutoring time amongst the tutees, working with groups of three; and sometimes there were five tutors allowing for one-on-one tutoring. This logistical difficulty in getting teenagers to the tutees provides direct justification for developing an application that makes after school support available online.

Both the tutors and tutees had limited design experience. It takes time to become truly comfortable with the design process (Yip et al., 2013) and especially the younger children found it difficult to complete their prototypes in the available time. Ideally children must be given more opportunities to become comfortable with the methods and techniques of a design process. This applies to both age groups involved.

Language Barrier

As previously mentioned, there were some language barriers, but these are not an issue if you take care to overcome them. In this project they were handled through correct pairing of the tutors and the tutees. With regard to one of the researchers not understanding Afrikaans (the first language of all the tutees involved), the second researcher acted as translator. This added to the overall research time and effort, but in a country where there are eleven official languages this is not a rare situation in research.

In summary: Teaming up young children with teenagers has clear positive outcomes, especially in terms of motivating the young partners to participate fully in design tasks. When teenagers are given the responsibility to design and facilitate it instils confidence in them and they will gain trust from the young children they are assisting. Young children bring to the design table an unrestricted imagination that does not necessarily provide crucial information about functional aspects of an application, but their ideas often shed light on what they would require in terms of interaction.

While our project provides an exciting opportunity for children to help develop a novel system that can greatly impact on children in less privileged communities, it also raises some difficulties regarding co-design. We have shown that some of the difficulties can be overcome by including both teenagers and young children in the design process: a wide range of design ideas are generated (from purely functional to purely decorative); young partners are better motivated to participate in design by the presence of teenagers; the young designers can learn from the teenagers about design; and the adult designers can use the teenagers as a communication channel to engage with the young partners, avoiding the inhibiting effect adult-child power relations may have on the young children.

Acknowledgments

This work is based on research supported in part by the National Research Foundation of South Africa. It is also partially funded by the research offices of the University of South Africa and the University of Pretoria respectively.

References

Barnard, G., & Joss, E. (2012). *How South Africans use their cell phones*. Retrieved July 10, 2014, from http://www.xcellentmedia.co.za/blog/how-south-africans-use-cell-phones-infographic

Benton, L., Johnson, H., Ashwin, E., Brosnan, M., & Growemeyer, B. (2012). Developing IDEAS: Supporting children with autism within a participatory design team. *Proceedings of CHI 2012*, 1759-1764.

Burton, S. J. (2006). *An investigation into participatory design with children - Informant, balanced and facilitated design.* Unpublished BSc(Hons) Computer Science project, University of Bath.

Butgereit, L. (2007). Math on MXit: The medium is the message. *Proceedings of the 13th Annual National Congress of the Association for Mathematics Education of South Africa* (AMESA).

Chimbo, B., & Gelderblom, J. H. (2012). Cross-age tutoring via social media: Motivating teenage tutors to engage in activities for the benefit of younger children. *Proceedings of the IADIS International Conference on Internet Technologies & Society, Perth*, 167-174.

Chriswick, B., Lee, L. Y., & Miller, P. (2003). Schooling, literacy, numeracy and labour market success. *Economic Record*, *79*(245), 165-181.

Department of Education. (2011). *Report on the annual national assessments (ANA 2011)*: Pretoria.

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

Druin, A. (2005). What children can teach us: Developing digital libraries for children with children. *Library Quarterly*, *75*(1), 20-41.

Farrell, G., & Isaacs, S. (2007). Survey of ICT and education in Africa: A summary report, based on 53 country surveys. Washington, DC: infoDev / World Bank. Retrieved July 10, 2014 from http://www.infodev.org/en/Publication.353.html

Feza-Piyose, N. (2012). Language: A cultural capital for conceptualizing mathematics knowledge. *International Electronic Journal of Mathematics Education, 7*(2), 62-79.

Fleisch, B. (2008). *Primary education in crisis: Why South African schoolchildren underachieve in reading and mathematics*. Cape Town, South Africa: Juta.

Fitton, D., Read, J. C., & Horton, M. (2013). The challenge of working with teens as participants in interaction design. In *CHI'13 Extended Abstracts on Human Factors in Computing Systems,* ACM: 205-210.

Guha, L. M., Druin, A., & Fails, J. A. (2013). Cooperative Inquiry revisited: Reflections of the past and guidelines for the future of intergenerational co-design. *International Journal of Child-Computer Interaction*, *1*(1), 14-23.

Hussein, A., & Nassuora, A. B. (2011). Academic attitudes towards the use of mobile phone technologies for knowledge sharing in higher education institutions: An exploratory survey. *American Academic & Scholarly Research Journal, 1*(1), 6-9.

Little, L., Bell, B., Defeyter, G., Read, J. C., Fitton, D., & Horton, M. (2013). Behaviour change interventions: Teenagers, Technology and Design. *Proceedings of IDC 2013.* ACM: 610-612.

Madden, M., Lenhart, A., Duggan, M., Cortesi, S., & Gasser, U. (2013). T*eens and technology. Pew Internet & American life project*. Retrieved July 10, 2014 from http://pewinternet.org/Reports/2013/Teens-and-Tech.aspx

Mji, A., & Makgato, M. (2006). Factors associated with high school learners' performance: A spotlight on mathematics and physical science. *South African Journal of Education, 26*(2), 253-266.

Mogotlane, S. M., Chauke, M. E., van Rensburg, G. H., Human, S. P., & Kganakga, C. M. (2010). A situational analysis of child-headed households in South Africa. *Curationis*, 33(3), 24-32.

Muller, M. J. (1991). PICTIVE – An exploration of participatory design. *Proceedings of CHI 1991*, ACM.

Nerantzi, C., & Beckingham, S. (2014). Using social media in the social age of learning. *Lifewide Magazine, 10* (June 2014). Retrieved July 10, 2014 from http://www.lifewideeducation.co.za

Nesset, V., & Large, A. (2004). Children in the information technology design process: A review of theories and their applications. *Library & Information Science Research*, *26*(2), 140-161.

Roy, A., Kihoza, P., Suhonen, J., Vesisenaho, M., & Tukiaianen, M. (2014). Promoting proper education for sustainability: An exploratory study of ICT enhanced problem based learning in a developing country. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, *10*(1), 70-90.

Snyder, C. (2003). *Paper prototyping: The fast and easy way to design and refine user interfaces*. Morgan Kaufmann.

Seekoe, K. (2010). "No hope, no future" for SA pupils. *Mail and Guardian Online*: Johannesburg. Retrieved March 17, 2014, from http://mg.co.za/article/2010-10-08-no-hope-future-for-sa-pupils

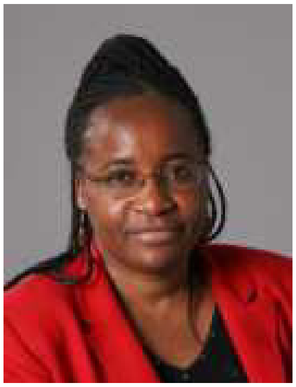
Taylor, N. (2011). *Priorities for addressing South Africa's education and training crisis.* National Planning Commission, A Review commissioned by the National Planning Commission, JET Education Services., Johannesburg.

Winthrop, R., & Smith, M. S. (2012). *A new face of education: Bringing technology into the classroom in the developing world*. Washington, DC: Brookings Institution.

Van der Berg, S., Burger, C., Burger, R., de Vos, M., du Rand, G., Gustafsson, M.,..... von Fintel, D. (2011). *Low quality education as a poverty trap in South Africa*. University of Stellenbosch, Cape Town: Department of Economics.

Yip, J., Clegg, T., Bonsignore, E., Gelderblom, H., Rhodes, E., & Druin, A. (2013). Brownies or bags-of-stuff? Domain expertise in cooperative inquiry with children. *Proceedings of. IDC 2012*, 201-210.

Biographies



Bester Chimbo is a Lecturer in the School of Computing at the University of South Africa, where she teaches courses in Formal Logic and Human-Computer Interaction. Bester is pursuing a doctorate and her research focuses on designing with children for children.

Helene Gelderblom is an Associate Professor in the Informatics department at the University of Pretoria, where she teaches courses in Programming and Human-Computer Interaction and supervises Master's and Doctoral students. Her research focuses on designing for children and other special user groups as well as on the design of technology for education.