Structured Approaches to Participatory Design for Children: Can targeting the needs of children with autism provide benefits for a broader child population?

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Abstract In the past technology products created to overcome accessibility and usability issues experienced by individuals with special needs have also resulted in greater usability for the wider population. Recently, researchers have developed tailored approaches to involving special needs populations in the process of designing this technology, but it is not known if these approaches could also benefit participation in a wider population. This paper investigates the potential benefits of using a new participatory design (PD) approach, tailored to meet the specific needs of a minority group, children with Autistic Spectrum Disorders (ASD), for typically developing (TD) children (i.e. mainstream school children). Our approach, known as IDEAS (an Interface Design Experience for the Autistic Spectrum), provides structure and additional support targeted at specific ASD impairments, with the level of support able to be tailored to the needs of individual children. A study has been undertaken to trial this approach with two TD design teams. The findings reveal that the children benefited from the additional structure within the idea generation process, enabling them to feel more comfortable sharing and developing their ideas, as well as interacting with other group members.

Keywords Participatory design • Technology design • Children with special needs • Structured design process

Introduction

Many researchers argue that considering the needs of users with particular special needs when designing products or services can result in "better solutions for all users by providing multiple choices", (Dolan and Hall, 2001). Dickinson et al. (2003) also suggest it is possible to achieve better practice for all through the sensitive consideration of "the needs and capabilities of particular user communities" during the software design process. For example, they propose that improving the reading experience for dyslexic users within software may also benefit elderly and visually impaired users. However, inclusive approaches to design principally focus on the usability of the resultant *product*.

Our research aim is to investigate if targeting an approach for involving users in the technology design *process* to the specific needs of a minority group could have a wider benefit on the involvement of a more general population. This paper investigates the potential benefits of using a PD approach, developed to meet the specific needs of children with ASD, with TD children. Our approach, IDEAS, provides explicit structure and support for the known difficulties associated with ASD (Benton *et al.*, 2011; Benton *et al.*, 2012). These include issues with communication, collaboration and creativity (APA, 1994; Craig and Baron-Cohen, 1999). In this case 'structure' relates to the environment and organisation of the design activities, whereas 'support' refers to the additional help given for individual design activities. Given the research findings of Dolan et al. (2001) and Dickinson et al. (2003) noted above we assess if the IDEAS approach supports TD children's participation within design sessions.

The rationale for a structured approach to the design process has been inspired by the structured teaching approach used within the TEACCH program (Mesibov *et al.*, 2007), an international educational program for individuals with ASD. The TEACCH approach considers the behaviours observed in ASD on an individual basis, along with underlying reasons for these behaviours. It recognises the difficulties as well as personal strengths and interests, and provides specific supports and problem-solving strategies to help with all aspects of development.

TEACCH is grounded in both research and clinical literature and supports Rutter and Bartak's (1973) view of a structured classroom, where it is important that structure is not achieved through any form of rigidity, rote learning, or forceful discipline.

The main aim of our research is to investigate if adopting a structured approach to the involvement of children in the technology design process can be effective in overcoming potential difficulties associated with individual characteristics or prior experiences. The goal of this approach is to provide children with the opportunity to undertake the highest possible level of involvement (allowing the greatest contribution) within the PD process over a short defined timeframe, as many research projects often do not have the resources to involve children for extended periods of time to build up this involvement more gradually.

Participatory design for children

For over a decade PD methods have been developed specifically for children. Druin (2002) proposed a number of factors to be considered when designing with children, including their current developmental stage and level of involvement. Druin (2002) defined different levels of involvement for a child within the technology design process describing four distinct roles: User, Tester, Informant and Design Partner. These roles range from the child having minimal involvement and influence (User) to being seen as an equal stakeholder with the same opportunities to be involved and to contribute as adults (Design Partner). However, this optimum level of involvement is not always possible due to the resources available, and the age or special needs of the child (Guha *et al.*, 2008). This raises the question of what role children with a special need such as ASD could potentially undertake, and questions how much their level of involvement is dependant on specific support to overcome their inherent difficulties.

The impairments characterising ASD (APA, 1994) have implications for participation within the technology design process due to issues with tasks such as thinking of a range of ideas and communicating ideas to other team members. However, these difficulties could also be experienced by typically developing (TD) children, albeit to a lesser extent. TD children can vary in their rate of cognitive development resulting in some children experiencing prolonged issues with egocentricity or difficulties with abstract thinking. Individual personalities and previous experiences can also result in children struggling with self-confidence, interacting with adults or undertaking imaginative activities, particularly if they are from a rote-learning style background. Therefore providing support for the difficulties experienced by children with ASD also has the potential to help individuals from a TD population.

Druin (2002) suggests a preference for children being involved within the design partner role throughout the design process. However, it can take up to six months for children to become comfortable in their roles as design partners (Druin, 2002) and having the 'luxury' of this amount of time to build up to this role is something many research or practical projects needing children's input, do not have.

Large et al. (2006) have proposed an alternative model to involving children called "Bonded design" which falls between the informant and design partner roles. The Bonded design methodology shares the goal of design partnering, of children playing an active role in the design process and working as part of an intergenerational team, but questions whether a "full and equal cooperation can be established across the generational divide", (Large *et al.*, 2006). Large et al. found that Bonded design worked successfully over a shorter time period (9-12 sessions) than was usual for design partnering and also within a school environment rather than a university lab. However, they did encounter a number of issues, which included:

- Difficulties with children taking things literally during sessions (i.e. when using analogies)
- Children being unhappy when their ideas were not included
- Children finding it difficult to compromise and discard their own ideas (even if they were impractical or unpopular)
- Some children dominating brainstorming sessions when in small groups
- Children spending too long drawing and finding it difficult to focus on one specific design element
- Difficulty finding the balance between showing examples and giving the children more creative freedom

Large et al. (2006) recognised there was a need for the adults to organise the sessions, set the research agenda, and when necessary manage behaviour and engagement in the tasks. This makes it difficult to overcome the power imbalance between the children and adults within the team, to allow the children to feel their contributions are viewed as equal to those of their adult counterparts, particularly over a relatively short time period. This paper aims to build on this work to assess if the structure underpinning the IDEAS approach can overcome the above difficulties, focussing on the shortened time period and power imbalance issues.

This paper firstly describes an analysis of existing PD methods for children and a pilot investigation into the use of the IDEAS approach for representative design activities with individual children and the effect this had on the creative processes followed by the children. The extended version of the IDEAS approach, which additionally incorporated structure and support for collaboration, is then presented along with a trial of the approach with two design teams that included TD children. The findings from these PD sessions are discussed in terms of implications for future work in this field.

Analysis of existing PD methods

The TEACCH characteristics (Mesibov *et al.*, 2007) cover the fundamental features of autism and include: difficulties with the concept of meaning; greater focus on details and lack of ability to prioritize their relevance; distractibility; concrete vs. abstract thinking (limited social skills/emotional empathy); combining or integrating ideas; organizing and sequencing; generalization; visual vs. auditory learning; prompt dependence (difficulty with initiation); strong impulses, and excessive anxiety. We applied the TEACCH characteristics of the culture of autism to the PD context by defining a set of criteria based on the potential issues introduced above, that children with ASD (or ASD characteristics) may encounter during the PD process. These criteria were used to analyse a number of existing PD methods for TD children to determine their suitability for use with an ASD population. It was found these existing methods each had different elements potentially appropriate for this population. To ensure each TEACCH-based criteria was supported these appropriate elements were combined with some novel features to form the IDEAS approach.

The analysis focused on PD methods that had been well documented and previously used successfully with TD children. These included:

- Cooperative Inquiry (Druin, 1999), incorporates a number of techniques including contextual inquiry, participatory design and technology immersion
- Bluebells (Kelly *et al.*, 2006), incorporates design activities based on childhood games
- Mixing Ideas (Guha *et al.*, 2004), incorporates structured support to help young children combine their ideas
- IBF Model (Read *et al.*, 2002), considers different balances of participation
- Comicboarding (Moraveji *et al.*, 2007), aimed at children from a rote learning background and uses comicbook templates to scaffold ideas

The IDEAS approach has been designed to support the TEACCH characteristics, to prevent any one of them becoming a barrier to successful involvement in the design process. TD children may also experience similar difficulties in some of these areas and any potential difficulties encountered during the design process will also depend on their current stage of development (Piaget, 1977). The difficulties experienced by TD children could potentially include:

- *Distractibility* – many children can struggle with paying attention and keeping on task.
- *Concrete vs. abstract thinking* – younger children and those who progress through the stages of development at a slower rate can struggle with understanding abstract concepts.
- *Combining or integrating ideas/Difficulty with initiation* – younger children or those with more egocentric personality traits can struggle with combining their design ideas with others, and compromising on parts of their design ideas to ensure everyone has some input into the group idea.
- *Difficulty with initiation* – children with little experience of participating in creative activities, such as those from rote-learning backgrounds could struggle with generating their own original design ideas.
- *Excessive anxiety* – children with low self-confidence, difficulties with socialising or anxious personalities could be apprehensive about taking part in an unknown process and working with unfamiliar adults.

Table 1 presents the different structure and support mechanisms incorporated within the IDEAS approach, how they overcome each of the TEACCH characteristics mentioned above and (where relevant) the existing PD method that the mechanism has been inspired by.

Table 1 Structure and support mechanisms incorporated within the IDEAS approach

Structure Mechanism	**TEACCH Characteristic**	**How Overcome?**
Environment	*Distractibility*	Sessions undertaken in a quiet environment away from busy classroom (IBF Model).
	Excessive Anxiety	Sessions undertaken within a familiar environment at the children's school.
Visual Schedule	*Distractibility*	Give session focus/goal through listing tasks to be completed, helping re-engage children in the current task and reinforce the session rules if children behave inappropriately.
	Excessive Anxiety	Allows the children to see the next activities so they are prepared for the different tasks and do not become anxious about the unknown. Helps build confidence by giving children ownership over the sessions through agreement of rules and responsibility of checking off completed tasks.
Support Mechanism	**TEACCH Characteristic**	**How Overcome?**
Adult Support (1:1 attention, prompting, praise)	*Distractibility*	Adults incorporate children's hobbies and interests where possible (Bluebells).
	Combining Ideas	Adults support individual children to combine individual design element ideas into the group idea (Mixing Ideas).
	Difficulty with Initiation	Adults prompt children for ideas or make suggestions if struggling with idea generation.
	Excessive Anxiety	Adults can provide 1:1 support if a child becomes anxious (Mixing Ideas).
Activity-specific Support (Existing technology examples, idea templates, computer and paper-based prototypes)	*Concrete vs. Abstract Thinking*	Design topic introduced in a concrete way via the demonstration of existing software (CI) and ideas converted into computer-based version rapidly.
	Combining Ideas	Idea generation is staged, with templates provided for different elements of design topic and also for both individual and group ideas.
	Difficulty with Initiation	Idea templates contain initial design topic idea with space for children to add more ideas (Comicboarding).
	Excessive Anxiety	Idea templates provide structure for idea generation, so the children are not presented with just a blank piece of paper (Comicboarding). Art supplies limited to reduce anxiety over choice and potential sensitivities to some materials.

These mechanisms were firstly piloted on individual children to investigate the extent to which they might benefit from additional structure and support for design activities and then were later refined to additionally apply within a collaborative design environment. The initial pilot of the IDEAS approach is described in the following section.

Pilot study – Phase 1

Aim of Study

The aim of the pilot was to trial the structure and support mechanisms for representative design activities, such as idea generation and low-tech prototyping. The first phase of the IDEAS approach was undertaken with single individual children in one-off sessions, removing any potential issues with collaboration influencing the children's ability to undertake the activities. The sessions were structured through the use of a visual checklist, which displayed each of the session tasks, pictorially and textually, allowing the child to check off each task as it was completed. Each task had two levels of support, every child began at the lowest level of support but if they experienced difficulties completing the activity they were provided with additional support. Paper-based templates were used to guide generation and documentation of ideas, and also at the higher level of support provide example ideas where needed (see Fig. 1). Templates were also used for low-tech prototyping and where children had problems with novel idea generation they also provided the children with the start of a visual design idea to which they could then add their own ideas/modifications (see Fig. 2).

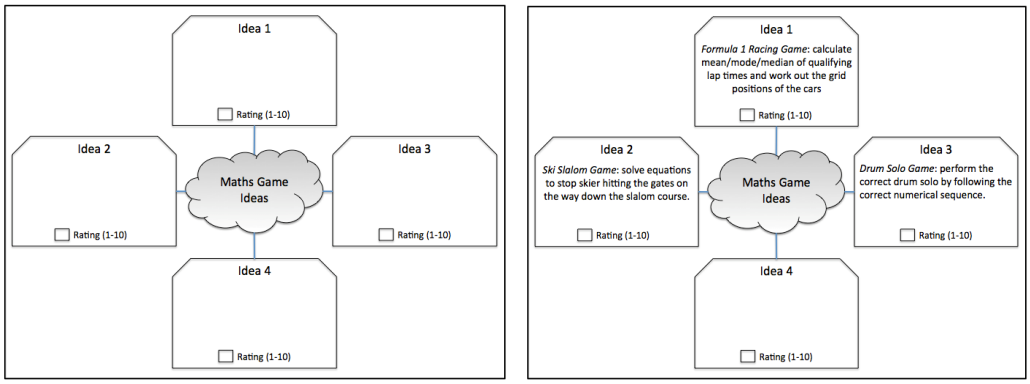

Fig. 1 Low support (left) and high support (right) ideas templates

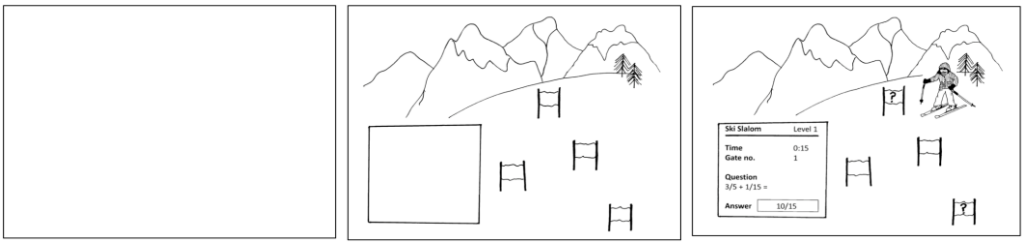

Fig. 2 No support (left), basic support (centre) and high support (right) visual design templates

Participants

Ten TD children (nine boys and one girl) took part, and were tasked with designing a maths game for secondary school pupils. This task was chosen as this work formed part of a wider project to design a maths tutoring system for secondary school pupils. The unbalanced gender split was due to matching with another group of children with ASD (not discussed in this paper), ASD being more prevalent among males. The children attended two urban non-faith secondary schools and were aged between 11 and 14 years.

Procedure

Each session took place in the children's school in a separate room and with an experimenter administering the tasks, answering the children's questions and providing additional support when required, but not directly participating in the session. The experimenter took notes and photos periodically to document the session. There was no time limit set on the sessions, the tasks had to be completed within a single school lesson of 50 minutes, but all of the participants finished well within this time and so this did not present an issue. Prior to the sessions a survey to establish the typical hobbies and interests of ASD and TD children was undertaken

with 29 children with ASD, and 88 TD children. Images of the most common hobbies/interests from this survey, as well as common interface icons such as play, stop, mute and back buttons, were provided as an option for the children to cut out and incorporate into their interface design. The sessions included the following tasks, which were explained to the child at the start of the session and also displayed on the visual schedule:

1. Introduction to session using visual schedule to show tasks visually, participant instructed to check off each task as it is completed.
2. Discussion of previous experience of maths and computers. Examples of two existing maths games shown on laptop followed by short verbal discussion about good/bad points.
3. Generation of ideas for new maths game using template with appropriate level of support (Fig. 1) as determined by the experimenter, to document each idea. The child then rates each idea out of 10 to help evaluate which idea they think is the best.
4. Development of favourite game idea into visual paper-based design, using appropriate template (Fig. 2), limited art supplies (i.e. pencils, felt pens, glue) and selection of pre-drawn images based on typical hobbies/interests. Design then placed in a cardboard computer mock-up and participant asked to verbally explain game.

Results of Pilot

All of the participating children were able to successfully generate at least 2 maths game ideas, produce a paper-based interface design based on their favourite idea (see Fig 3 for examples) and explain this design coherently to the experimenter. Each distinct maths game title/description written on the template was counted as one idea. It was found that the children on average generated 3.7 ideas, with 8 of the 10 children generating 3 or more (range 2-7, median = 3), although some children needed to be encouraged by the experimenter to generate further ideas after their initial idea. Every child was also able to generate an idea that was distinctly different to the example games shown. Each session took on average 27 minutes to complete (range = 15-40 minutes).

All of the children were able to complete the session using the basic level of support. There were some concerns about drawing ability, with one child having to be prompted to draw his idea rather than explain it verbally, and other children stating that they were not very good at drawing. Most children appeared from the ratings to be confident about their ideas with the average rating for their favourite idea being 8/10, although one child did not seem confident about the task or his ideas, rating them 5/10 and 2/10. Three children chose to use the additional hobbies/interests based images provided, either using them as characters within their game or as an additional part of their interface not central to the game (icons).

The cardboard computer mock-up helped some children explain their idea, for example one child mimicked using a mouse to explain his idea, and two children realising they had missed out elements of their game after viewing it in the mock-up.

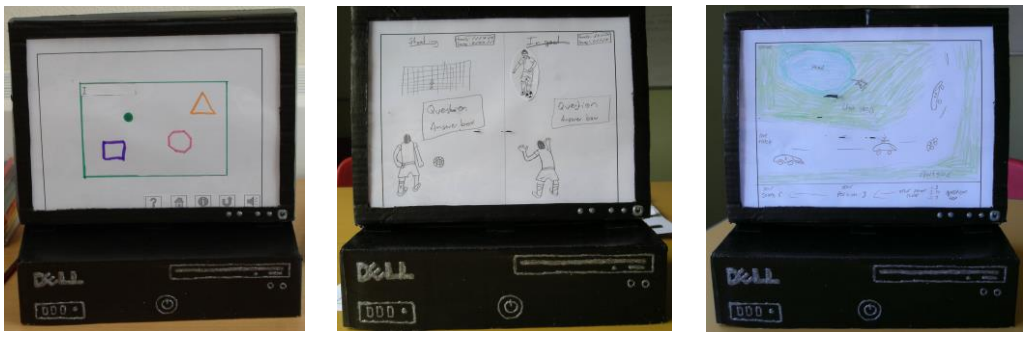

Fig. 3 Example game designs

These results indicate that although TD children may not require additional *support* to complete typical design tasks successfully, providing additional *structure* to the idea generation process may be useful in encouraging the children to contribute more ideas when working within shorter timeframes, as all children were able to generate multiple ideas, evaluate these ideas and develop one idea into a visual paper-based design within 40 minutes. However, this was an individual activity designed to understand how to support the creative process, so that this does not create a barrier to team participation. It does not indicate that there would be no requirement for additional support, for instance if children struggle to generate ideas due to concerns about other team members' opinions or because of distractions from other team members. There is also a potential need for supporting those children who exhibit confidence issues with idea generation or

drawing ability which are issues a collaborative design environment could exacerbate. This is something that is investigated as part of further development of the IDEAS approach, described in the next section.

Design team study – Phase 2

Aim of Study

The aim of this study was to investigate the use of additional structure and support for collaboration within a design team. The second phase of the IDEAS approach was refined based on the results of the pilot study. It included similar activities to those in the first phase undertaken over six separate design sessions over a six-week period and the team ideas were further developed into an animated computer-based prototype. The visual checklist providing the session structure was further developed into a whiteboard-based visual schedule. The whiteboard also displayed information about the session, including an agreed upon team name, participant portraits/names and a set of rules agreed by the team during the first session to help guide behaviour and social interaction (see Fig 6). Allowing the children to provide input into the session structure and rules, and check off the session tasks was designed to give the children a sense of empowerment and ownership over the sessions.

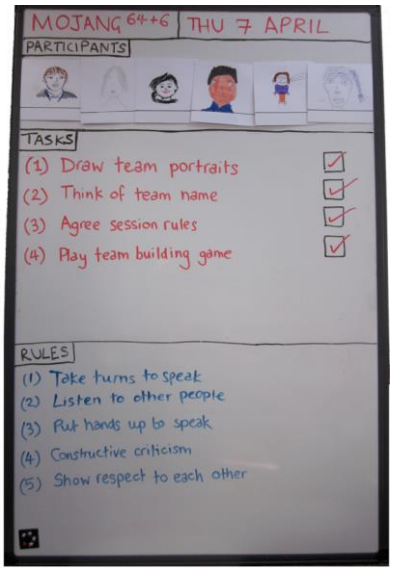

Fig. 6 Whiteboard-based visual schedule

Session Design

Every session follows the IDEAS approach by having a clear goal based on specific TEACCH characteristics, as described below (with TEACCH characteristics in brackets):

- *All Sessions* – conduct in a quiet environment away from classroom (*distractibility).* Incorporate a consistent structure, beginning with a visual recap of the previous session, and using the visual schedule an explanation of the tasks to be completed and a reminder of the session rules (*organizing and sequencing; visual learning)*. This helps act as a memory aid for the children, focuses them on the 'big picture' (*greater focus on details)* and also creates a familiar environment that the children feel comfortable participating within (*excessive anxiety)*. Involve a familiar member of teaching staff to help reduce fixations on special interests and incorporate these interests appropriately (*strong impulses; excessive anxiety*).

- *Session 1: Team Building (limited social skills/emotional empathy)* – focuses on developing a team identity and building up team work skills, by using fun, team-based tasks and games, to help initiate and structure initial interaction between team members.

- *Session 2: Context Setting (concept of meaning; generalization)* – introduces the design topic in a concrete way through discussions of each team member's previous experiences and through demonstration of existing similar technology.

- *Session 3*: *Idea Generation (combining and integrating ideas; prompt dependence)* – structures the idea generation process and involves team members generating individual ideas for defined elements of the design topic, documenting them on paper-based templates and then verbally explaining them to the rest of the team. Child team members are then each responsible (aided by an adult) for combining the most popular ideas for one element of the design topic onto a larger paper-based template (e.g. Fig 7).

- *Session 4*: *Design Development (concrete vs. abstract thinking)* – moves onto generating ideas as a team. The team are shown computer-based still frames of their ideas from the previous session and asked to annotate paper-based versions of these with ideas for improvements. Paper-based versions of the ideas are used to ensure that no specialist skills are required to record further ideas. This task is repeated for each design topic element.

- *Session 5*: *Design Refinement (concrete vs. abstract thinking)* – provides further opportunity for team idea generation and is structured by design topic element as in session four. The team are first shown a computer-based animated prototype of their ideas for each element and asked to annotate ideas for further improvements on a paper-based version.

- *Session 6*: *Evaluation and Reflection (concept of meaning)* - involves the evaluation of the final computer-based prototype and also an opportunity to reflect on the participation experience. Team members are asked to complete surveys to identify their opinions of the prototype and their own experience. The team also work together to produce a display of the work completed over the previous five sessions.

Fig. 7 Paper-based template of team ideas for one game element

Participants

Two teams took part in this study using the extended IDEAS approach. Each team consisted of three TD children and also three adults, including one member of teaching staff from the children's school and two university researchers, one with a computer science, and another with a developmental psychology background. Each team was multi-disciplinary involving adults familiar with the school environment and the children, and also adults familiar with the technological and psychological aspects of the sessions. Having three adults ensured that the children could be supported on a one-to-one basis during the sessions if required, with the adults providing support through the use of prompts and praise to ensure every child made a contribution and to reinforce appropriate behaviours.

The child participants were aged between 11- 13 years and attended two urban non-faith English secondary schools. The CUP team included two boys and one girl, and team PNW included three boys. The children's verbal IQ was assessed prior to the first session, with one child from each team classified by the Wechsler Abbreviated Scale of Intelligence (WASI) as Low Average and the two other children classified as Average.

Procedure

The team's overall session goal was to improve upon the feedback for getting a correct/incorrect answer, and the reward scheme used within an existing maths game for secondary school children. It was decided to focus on these specific elements to provide additional structure within the idea generation process through a clearly defined brief. It was intended that this would help guide initial idea generation, giving the children more than a blank piece of paper to work with, but still allow the creative freedom to generate ideas for additional game elements where appropriate.

The sessions were conducted on a weekly basis in a quiet environment away from other class activities and were designed to be engaging, fun and relaxed. The children were rewarded for taking part by being allowed 5 minutes at the end of each session to play games on an iPad.

Post-Session Evaluation

During the last session the child participants were asked to complete two surveys. The first survey was administered during the session after the team had been shown the final version of the computer-based prototype game and focused on the children's opinions of the final game idea. The second survey was administered by the teacher after the session and was focused on the children's opinion about their experience of taking part in all six sessions. Each survey included 11-12 questions and incorporated a Smileyometer Likert rating scale (see Fig 8). This survey instrument re-developed by Read et al. and co-designed by children (Read and MacFarlane, 2006), allows the children to express their opinions about both the different game elements and also the different PD activities they undertook. Each member of teaching staff that took part in the sessions also completed a survey to gather feedback about whether they thought the children benefited from their participation in the sessions, and in what ways.

Fig. 8 Smileyometer rating scale used in surveys

Results

The study results have been considered in terms of how the structure and support benefited the children's of teamwork skills, ability to generate ideas, and perceptions of their experience, and also the quality of the game it enabled them to produce.

Teamwork

Generating a team name during the first session provided the design teams with an opportunity to establish a shared identity, with both teams incorporating information about the team members within their name. The CUP team name was formed from the first initials of the children's learning community names and also the first initial of the university name. The PNW team name was formed from the first initials of the towns where each of the boys lived. However, the boys in PNW found actually working together as a team much easier than the children from CUP. For instance, during the initial team-building activity, a Lego building task, the boys from PNW decided to keep switching roles so everyone had a chance to instruct, gather bricks and build the game, helping one of the quieter boys become more involved. They were able to work together without adult intervention.

In contrast within the CUP team there was evidence of difficulties with this task. The girl became very frustrated with one of the boys who was building the game incorrectly but was unable to clearly explain to him what he was doing wrong. This required the intervention of adult team members to help her explain the issue and ensure the boy understood. One of the boys in CUP was also very quiet, hesitant to contribute ideas or opinions and would frequently be ignored by the other two children during social conversation. However, with adult team members prompting him for ideas, listening to him and providing positive feedback, he grew in confidence over the sessions and during the fifth session the girl listened to his ideas and actively agreed with him. By the last session all of the children from the CUP team demonstrated the ability to work well together on the final activity of making a display of their work, in a manner similar to the way the children from PNW also completed this activity, by sharing the tasks between them and making joint decisions, for example on the title of the display. This showed the progress the CUP team had made from the first session in terms of teamwork.

Idea Generation

The children in both teams were all able to contribute appropriate ideas during the sessions, which resulted in a final prototype game that fulfilled the original brief. The boys in PNW managed to generate and share their individual ideas with minimal intervention from the adults during session three. The children in CUP required much more support to do this. It became clear that the girl had very low self-confidence and was very reluctant to share her ideas initially. However, after much prompting from both researchers and the teacher, as well as praise for any ideas that were shared, she grew in confidence and volunteered to be the first one to share her ideas with the group in session three. This indicates that the combination of the adult support and also the consistent structure of the tasks (enabling the children to become familiar with what is expected for each task), helped to construct an environment in which the girl felt increasingly comfortable to participate. The children from CUP also appeared much more engaged during the last task of session three which was to combine the individual ideas into an initial group idea and involved working one-to-one with an adult team member. In contrast during this task the children from PNW were happier working on their own, with occasional input from the adult team members.

Both teams initially struggled to generate ideas during sessions four and five, which involved firstly animating the interface design stills and then improving upon the animated game prototype videos. The idea generation was divided into three tasks for the three different game elements (correct feedback, incorrect feedback and reward scheme) and it was found that the children needed considerable prompting during the first task but this typically decreased during the second and third tasks with the children initiating more of the idea generation. This was particularly apparent in the case of one boy from CUP who had concentration issues and initially was only able to generate very basic ideas as he struggled to engage in individual idea generation tasks. He frequently became distracted and had to be prompted both to make further contributions as well as to correct his behaviours (such as looking at his mobile phone). However, over the course of the session tasks he was prompted less, and there was also evidence of a decrease in the overall prompts needed from session four (51 prompts) to session five (37 prompts) as he became more familiar with the idea generation structure.

The boys in PNW seemed to struggle during session five and suggested almost half the ideas than in session four and just over half the ideas the CUP team generated during the same session. An idea in this case was defined as a new task-related suggestion that was not an extension of a previously suggested idea. The boys were very enthusiastic about the animated prototype and described all elements they liked and why they thought they did not need to be changed because it already looked good. The more ‘polished’ look of this prototype could have potentially contributed to this resistance to make further improvements or changes. There was initially a similar resistance within the CUP team, but following a suggestion from the teacher it was found that repeatedly demonstrating the animated computer-based prototype prompted many more ideas from the children. This is therefore something that would be useful to explicitly include within future refinements of the IDEAS approach.

Benefits of Participation

In the survey about their experience of participating in the sessions the children in both teams on average rated the experience of designing the maths game and working with the team as ‘Really Good’ (lowest rating was ‘Good’). Every child said they would take part again, with all the children from the CUP team adding ‘Definitely’ to their checked answer. Only two of the children said they would not recommend a friend to take part as they did not want a friend to take part instead of them! The children were also all very positive about the specific tasks of generating ideas, drawing out their ideas, and sharing them with the rest of the team. Both teachers involved in the sessions felt that the children had benefited from participating and thought that they learnt about listening to and respecting each other’s ideas, working together and coming up with their own ideas. The teacher from the PNW team said the sessions highlighted the benefit of small group work, whilst the teacher from the CUP team said: “The boundaries and rules which were set out made it easy for the young people to follow, as they were in charge of ticking each task I feel they owned the sessions, I am now using this in group sessions myself”. This demonstrated benefits for the teachers themselves as well as for the children.

Peer Opinions

The final prototype videos of the game were shown to a separate class of 23 TD secondary school pupils aged 11-12 years (the target audience for game). The identities of the participants responsible for designing the games were not revealed to the class. The majority of the children preferred the CUP team’s game with 14 children saying they would choose to play it compared to 4 children who would choose to play PNW’s

game. The children liked the CUP team game because of the point scoring system, the music, colours and general look of the game. In contrast the children found PNW's game a bit boring, sometimes confusing and thought there should be a 'bigger celebration' for completing the game.

Discussion and Future work

The findings from this study show that from both teams participants were able to come together as a team and produce a prototype game that fulfilled the original brief over a relatively short period of time. There were however some differences between the teams. The children from CUP exhibited issues with self-confidence, concentration, and shyness, which initially affected their ability to work as a team and also their general behaviour, which sometimes had to be managed by the teacher. The children from PNW demonstrated a more natural ability to work together and never had to be prompted to behave correctly, but they did struggle more with expanding on their ideas. It is not known if these children specifically struggled with creative thought, if they were hesitant to criticise due to a need to please the researchers, or if they were simply happy to stick with what they had. This issue along with any potential solutions would need to be investigated further before any firm conclusions can be drawn. The adult support and consistent structure provided an environment in which the children from CUP increased in confidence to share ideas and also provided a way to manage their behaviour. These children were more of a challenge to involve, but the results from the peer survey show they had good ideas and that a structured approach such as IDEAS has the potential to support children with particular issues (that may not necessarily be labelled as a specific 'special need') to successfully participate within the technology design process.

The following sections detail the findings from both studies in terms of the structure and support mechanisms presented earlier in this paper.

Environment

The children in both studies appeared comfortable within the school environment, however the children from the CUP team were still distracted when they could see other pupils outside the classroom and in the playground, demonstrating the importance of conducting the sessions away from a busy classroom.

Being out of lessons appeared to be motivating for the children, with some children keen to know when they would be taken out again and which lessons they would be missing.

Visual Schedule

The visual schedule appeared to have little influence in the pilot study, as it provided less information and also as the children only took part in a single session there was no time to build up any familiarity with the setup. During the design team study the children took their responsibility for checking off the tasks seriously, sometimes the children would volunteer to take on the responsibility before being asked and would also prompt each other to check off the tasks as they were completed. The list of rules were useful as a reminder to reinforce appropriate behaviour within the CUP team, and the teacher from this team was also impressed with the schedule and began using it within her own classes.

The children understood the concept that once a task was checked off they could move onto the next task. This was not always a positive feature however, during one session the children in the CUP team were keen to rush through the tasks so they could get more reward time and the boy responsible for checking off the tasks would stand by the board waiting to check the task off before the other boy had finished describing his idea. This made the other boy feel pressured to finish and he quickly wrapped up his explanation. It had to be explained to the children that they were being rewarded for their contribution to the session, and if they rushed through all the tasks quickly making little contribution they would simply go back to lessons early.

Adult Support

There was little adult intervention required during the pilot (other than encouragement to generate further ideas) as the children were able to complete the tasks successfully without additional support. In the design team study the adults were required to provide support in a number of ways. The children from CUP needed support to enable them to work well as a team and also to help them behave appropriately and engage within the tasks. The children from both teams needed to be prompted to help them elaborate on ideas and also to think about their ideas in greater depth by asking questions rather than just providing a high level basic description, something the children in the pilot were not required to do. The adults documented the team ideas on the paper-based template as the children seemed concerned about their spelling and drawing skills. It was also important for the adults to provide frequent praise to help build up the children's confidence to share their ideas within the sessions.

Activity-based Support

The children in the pilot study did not require the additional template-based support to generate ideas, but having a greater structure to the template may have helped them to generate multiple ideas. In the design team study the children were all able to add their own ideas to the individual templates (although the children from CUP needed some encouragement from the adults), however they seemed more hesitant to write on the group template in later sessions as it then became a shared resource. They discussed their ideas verbally and wanted one of the adults to document these ideas on the paper template. The children from both teams would often gesture to the computer-based prototype and the paper templates to help them describe their idea. Explaining their ideas verbally in this way enabled them to be shared with the whole team at once and also gave the other team members the opportunity to accept/reject the idea before it was written down.

Demonstrating existing games proved useful in engaging the children during the design team study, particularly as the children were all familiar with at least one of the games giving them confidence in having more knowledge than the adults on this topic. During the pilot the examples did not appear to influence the children's creativity negatively when generating their own original game ideas. However, in the design team study it is difficult to know if the children would have managed in the same way without the example game being provided as a starting point, as both teams included their ideas within the existing game concept and layout. The possibility of structuring the idea generation without providing an initial idea is something that will be investigated in future work.

The use of both paper and computer-based prototypes of the ideas proved successful during the design team study. The paper-based template provided a straightforward way to document ideas and allowed the children easy access to a prop to help explain their ideas. However, the computer-based version was more engaging when animated, exciting the children to see their ideas come to life and also serving as a useful prompt for generating further ideas when repeatedly demonstrated.

Limitations

Although there have been some positive findings from this study it is important to note that the IDEAS approach has only been undertaken with two TD design teams and it is difficult to generalise these results across a wider child population. Therefore this approach would need to be trialled with more children to determine if these results can be replicated and to what extent the children's individual characteristics and prior experiences do influence the session outcomes. There are also examples within this paper of when a structure does not work, such as the children rushing through the tasks by checking them off, so it is important to consider when it is appropriate to provide what kind of additional structure. Further development of the approach is required to assess which aspects of this structured approach are most valuable to the children and why.

It is clear from these findings that different children need support for different things, some children need support for their challenging behaviour, some to build up their confidence and self-esteem, and others to think more creatively and generate their own ideas. Using a structured approach like IDEAS can help to support these difficulties. Elements of the IDEAS approach can be found in a number of existing PD methods for children but the unique component of IDEAS is the combination of these elements within the TEACCH structured teaching framework, and particularly the emphasis on focusing on children's individual needs. The use of this type of structured approach appears to be effective for use over a short defined time period and also exploits the power imbalance between the children and the adults in a positive way, allowing the adults to provide a supportive environment to give the children the best possible chance to succeed in each activity.

For future work it is intended that the findings from this work could be incorporated into the development of a comprehensive toolbox that would be suitable for other researchers conducting PD sessions with children, to use. This toolbox would provide tailored support for children, both with and without 'special needs', with the ability to customize this support a key feature to ensure that children are supported in the activities they struggle with, but are still given as much creative freedom to develop their ideas as possible.

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