Capturing and Considering Idea Development in School Pupils' Design Activities

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There are many ways to look at the efficacy and value of the inclusion of children in design activities within HCI. Whilst the experience of participation can be highly beneficial for children, there is value, even if it is only to confirm the merit of the children's participation, in looking at the process of ideation and in considering to what extent children can ideate. Whilst design is by nature untethered, being able to capture and consider the diversity of design ideas across multiple design teams and to look at how such ideas are developed, can facilitate reflection and potentially improve practice. This work explores the diversity of ideas and the iterative development of ideas during the incremental design of a mobile game with 26 teen informants working in small groups over four design sessions. A method to visualize the evolution of ideas across design sessions is presented. Groups' behaviors are mapped to three positions according to how conservative and how innovative the participants were. We explore the implications of our work for practitioners and researchers.

CCS CONCEPTS • Human-centered computing ~ Interaction design ~ Interaction design process and methods ~ Participatory design

Additional Keywords and Phrases: Participatory Design, Children, Ethics, Method, Game Design, Teenagers, Ideas

ACM Reference Format:

First Author's Name, Initials, and Last Name, Second Author's Name, Initials, and Last Name, and Third Author's Name, Initials, and Last Name. 2018. The Title of the Paper: ACM Conference Proceedings Manuscript Submission Template: This is the subtitle of the paper, this document both explains and embodies the submission format for authors using Word. In Woodstock '18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages. NOTE: This block will be automatically generated when manuscripts are processed after acceptance.

1 Introduction

The HCI community has long advocated working with children in the design of technologies that they will use. This relationship has included asking children to evaluate software [23], asking children for ideas to improve software [10], and asking children for ideas for new interactive products [2]. In this latter role, as effective

contributors of ideas for, and designs associated with, new products, the HCI community refers to such practice using terms like co-design, co-creation and participatory design [3, 15, 20, 21].

This paper examines idea generation and evolution during a design activity that took place over four sessions with eleven groups of children. It provides the IDC community with a method to capture and then visual this idea evolution in order for designers to evaluate, and better understand, the participation of children in the design process. The method allows designers to better critique their studies and understand how their own assumptions could have affected the results. It is hoped that by doing this it will allow the community to improve and refine their own practices.

2 Background Work

The focus in our work here is on children's participation in design. By design in this context, we refer to the contribution of ideas in a process that takes its view from the Participatory Design (PD) practices that are widely reported in HCI. The broader questions about the value of children's participation in HCI research do of course include their inclusion in evaluation work but the intriguing nature of design, and the difficulties of quantifying such contributions are the focus for this paper.

Historically, children did not design interactive technology for themselves. The practice of involving children as co-designers is relatively new with its roots in the early work of Scaife and Rogers [22], and Druin et al. [2]. Over time there have been many papers that have explored children's participation in design. Many of these have described methods, methodologies and tools [5, 7, 24, 25, 26], a good number reflect on the inclusion of children from marginalized or non-typical groups [4, 5, 9, 14, 17]. There is a small set of papers that have begun to explore how ideas come from children during design [11, 18].

Researchers have begun to actively concern themselves with the ethics of the inclusion of children as evidenced in recent publications [6, 8, 19]. Core to the ethical debate on the participation of children in HCI research is the question of value. Looking at how children develop ideas in can shed light on the value of their participation and can contribute to discussions around 'mattering' [12]. Bødker and Kyng [1], wrote of the need to reinvent participation, especially in participatory design, so that it contributes real insights into real projects. Research into value has come to the forefront of the IDC community in recent years with initial work on value-centred design by Iversen et al. [12] informing the participants of the values of the design team in the design process. Nouwen et al [16] have looked at value-sensitive design and the values held by different stakeholders in the design process.

The main aim in most design studies is to emerge from the activity with design ideas. Whilst ideas are at the heart of participatory design activities, many experienced researchers struggle to see how these can be tracked and understood. Co-design, or PD, is a very messy process in which tracking ideas may appear counter-intuitive in many contexts.

Research in HCI generally focusses more on the make-up of design sessions and the social interactions of the design team than on the specifics of idea development. There are a handful of studies that partially quantify the ability of participants to develop ideas, for example, one study of family design over nine sessions did conclude that the longitudinal involvement helped the children develop 'expertise' as designers [27]. In co-design sessions with a single group of participants working on a single design task over multiple sessions, ideas can be tracked across sessions by keeping record of the time process and capturing points of interest. Walsh et al.'s [25] Layered Elaboration technique tracks ideas in this way by allowing for an initial design idea (a storyboard) to be modified and extended ('elaborated') using transparent overlay sheets. Walsh reports the success of this technique primarily in terms of progressing a design; in their work ideas are not quantified.

Read et al. [18], examined ideas in a multi-group single-session study. In this work, there was no elaboration of ideas but there was a concern studied in regards to the problem of having many participants each potentially offering the same ideas. This paper proposed a method for a systematic study of ideas that allowed a team to

examine a large set of designs and to reduce a set of ideas to a much smaller subset. Ideas were qualitatively rated and the best idea from each child's design was selected to go forward.

In a multi-group multi-session situation, design ideas are of interest across horizontal and vertical frames. Understanding at what point ideas may start to dry up over repeated sessions and also understanding the density and dispersion of ideas can help researchers to evaluate and compare their design sessions. With useful ways to think about idea development, researchers will be able to compare sessions, methods and methodologies and critically report on the value of design events with children in a hitherto unreported way.

3 Study

The activities we describe here are part of a large project around the development of outdoor games for children from across the world. We describe here a series of workshops, conducted over a four-week period, in which 31 young teenagers worked incrementally to design outdoor games for children that could be played using a mobile phone and a set of stones (real or 3D manufactured). Having the output from the sessions we were interested to examine how and in what ways ideas developed and changed in order to examine the value of having the teenagers participate.

The study took place in an 11- 16 school in the North of England. The participating pupils were all aged 13 and 14 (from a single school year group) and were selected by the school based on their interest in game development and their availability at the appointed time. The sessions took place in school time between 2.15pm and 3.30pm on four consecutive Wednesdays. The school obtained all the necessary consent forms from parents, and the pupils were under no obligation to take part and could opt out at any time.

3.1 Procedure

In Week 1 four props were provided by the design team to be used for the introduction to the activity and to evoke discussion and ideas. The props were:

- A box of games from around the world (these included ludo, snakes and ladders, card games and tiddly winks) – containing games pieces and instructions for the different games
- A box of card games – which included the playing cards along with instructions
- A simple children's shopping game that had been made out of cardboard.
- A handful of stones (purchased from a DIY store)

The design team introduced themselves to the pupils and began to talk about games that were played using physical objects. The game props were shown to the pupils and it was stressed that all the games came with instructions on how to play them. These were then discussed with the pupils. The pupils were then encouraged to talk about games they had played and about the instructions that came with such games. Next, the pupils were given a set of stones each to 'play with' and were asked to imagine and design games they could play with the stones and write the instructions required. The pupils were provided with pens and paper with which to complete the activity; this constituted OUTPUT1 of the design activity.

In Week 2 the pupils were again provided with handfuls of stones but were also shown an electronic version of the classic board game Monopoly. The pupils were asked to think about how simple games could be augmented using a smartphone with the example of augmented Monopoly as a prompt. Similar to Week 1, they were asked to design a game, that included the use of a smartphone and the stones, and asked to write instructions. The expectation was that the pupils would build on their earlier idea from Week 1 and so they were given OUTPUT1 to refer to, but not explicitly told they had to use this, whilst they created OUTPUT2.

In Week 3 the pupils were again provided with stones and encouraged to take out their smartphones but before they started to design the design team also spent a short time introducing them to the concept of the

Internet of Things. Objects such as smart devices (lightbulbs, speakers, voice systems etc.) were discussed alongside the ways in which these devices can connect with each other.

The pupils were then asked to think about a game, and instructions, that included some aspect of the Internet of Things. This became OUTPUT3 Once again, as in Week 2, the pupils had their earlier designs available to them as they worked.

In Week 4 the emphasis changed slightly as we worked towards a better specification of a game. The pupils were provided with pens, pencils and a specially prepared sheet that had outlines of smartphones and directional arrows and prompts. The pupils had all their earlier designs to refer to but were again not told to explicitly use them. The pupils were told to use the sheets to describe their game. The artefacts created in this session became OUTPUT4.

4 Analysis

At the end of the four sessions, the pupils' design work was collated with the aim to examine it to see the passage of ideas both between the groups and between the sessions. Only 11 of the 13 groups handed in all four outputs and therefore analysed (26 of the 31 pupils who had participated in the design sessions). The groups have been numbered 1 – 11. Analysis was done by the design team which was made up of three HCI researchers each with considerable experience in co-design and especially in co-design with children.

4.1 Analysis of diversity across multiple groups – using outputs 1, 2, and 3

To consider *Diversity of Ideas*; the design team sought to find a way to capture the variance across the different groups in each of the first three stages. The three early stages were chosen as they were an incremented design activity where, in each case, it could be expected that ideas would be further developed. We also anticipated that as the design space opened up and more things were brought (Smartphone, IoT) the ideas across the groups would become more diverse. The team each looked individually at each of the three outputs, 1, 2 and 3, for each design, and recorded three constructs:

1. To do: What players of the designed game would have to do
2. To win: What players of the designed game would have to do to win
3. Game Type: What sort of game was being described

The design team then came together to come to a consensus. At the same time, some 'cleaning' was carried out with references made back to earlier designs to ensure consistency of reporting. E.g., 'stack stones' and 'make a tower of stones' were initially used interchangeably so we agreed on a single way of describing the game idea of piling up stones, i.e., 'stack stones.'

4.2 Analysis of incremented design ideas – using outputs 1, 2, 3 and 4

To consider Incrementation of Ideas, of interest was the development (an idea being changed in such a way that it still can be related back to an earlier idea), stickiness (an idea remaining with little change) and loss of ideas (an idea being lost) within a group as the pupils progressed their design through the stages. This time, as Stage 4 was effectively an amalgamation and a deeper description of the game, it was decided that OUTPUT4 would also be included in the analysis as it represented the endpoint of the design process.

To frame the analysis, using a grounded theory approach, two of the design team looked at a sample of three of the outputs from stage 4 together with their associated outputs from stages 1, 2 and 3 and with discussion and consideration identified different things that could happen:

1. Ideas could be carried linearly from stages 1 to 2 to 3 to 4
2. Ideas could be seen in early outputs, e.g., in 1, and reappear in a non-adjoining stage e.g., OUTPUT4
3. Outputs could each contain widely differing ideas with no evidence of ideas sticking

Each member of the design team then looked individually at each design output (44 in total) and documented the ideas found within those outputs. The design team then came together to agree a set of ideas for each design

output and to find a common language to describe matching ideas (like 'stack of stones' and 'tower of stones') in the same way as earlier. Coding was again carried out with references made back to earlier designs.

The analysis process that was agreed on was to:

1. Examine OUTPUT1 and list the individual 'ideas' in the first column of a spreadsheet.
2. Examine OUTPUT2.
   - 2.1. For any ideas that have carried forward from OUTPUT1 enter each into column 2 on the same row as it was recorded in column 1.
   - 2.2. For any new ideas identified – add these in column 2 on a clean row beneath the row containing the last idea identified in column 1.
3. Examine OUTPUT3.
   - 3.1. For any ideas that have carried forward from OUTPUT1 or OUTPUT2 enter each idea into column 3 on the same row as it was previously recorded.
   - 3.2. For any new ideas identified – add these in column 3 on a clean row beneath the last idea identified in column 2.
4. Examine OUTPUT4 using the same process as above placing the results in column 4.

5 Results

In order to assist understanding the discussions about diversity and development of ideas, we begin this section describing some of the designs that were contributed.

5.1 Examples of Designs

The game ideas from the teens were varied and interesting. Some showed a lot more imagination than others, some contained more detail than others. Many of the games designed used ideas and gameplay, as well as themes, from existing games that the teens were familiar with. Figure 1 shows the end point of the design from a single group (Group 2), which we now discuss in more detail.

The first design output was a 'Pictionary'/'Rapidough' style game where one player had to make a representation of something out of stones and the other player(s) had to guess what was intended in the shortest amount of time. The second design output from Group 2 was a departure from the first game and involved dropping stones 'from the sky' to form the highest possible tower. The game only involved a mobile phone (not physical stones) and included different levels to complete of increasing difficulty. In contrast with the first design, this was specified as a single-player game. The design implied more interesting challenges that just building the highest tower, such as building a tower across a washing line. This game was specified as lasting approximately 30 seconds and was the only game to include this type of timing guidance.

The idea from Stage 3 was very different and combined both a mobile phone and physical stones. The game included visual symbols which were 'hidden' on stones, the set of symbols were shown in detail in the design, but this method of hiding was left ambiguous. The game involved following a physical trail in a woodland area and finding the special stones with symbols. Once a stone with a symbol was found it was 'scanned' with the mobile phone. The game was won by finding and scanning the stones; no mention of the number of players was made. A colour coding of symbols was mentioned, distinguishing between 'rare' and 'classic' symbols.

Figure 1: Group 2, Output 4.

The integrated design from this group is shown in figure 1 and it again differed from the previous designs. In this design, players had their own accounts for the game and used GPS on their phones to find virtual stones near to them. The player then walked to the (physical) location of the virtual stones which appeared on the phone (via augmented reality) as a 'hole in the ground' The game player had to stamp on the hole with their foot to collect the stone. The virtual stones then changed into animals and the objective of the game was to collect animals which could then be bred and traded. Animals upgraded over time and in-game purchases could be used to speed the upgrading process up. The game was completed by collecting all possible animal types.

5.2 Diversity across groups for the first three sessions

In Stage 1 there was quite a lot of overlap between the groups. Five of the eleven groups designed games based on stacking stones. Of these – three suggested concurrent construction – i.e., two at a time each building a tower at the same time. Concurrent construction was the most used gameplay idea. Three designs had the same winning mechanism which was that the last man standing was the winner. This was unsurprising given that so many had chosen stone stacking as a game idea.

In Stage 2 there was evidence of more diversity as the design task had more scope. At this stage there was a mobile phone in the mix, the stones were expected to still be there but in some cases the pupils had rather lost that idea. Only a couple of ideas were replicated – two groups had turn-based random play and two had challenges. By Stage 3 there was a little more similarity in game type with two groups making chance turn-taking games, two making collecting games and two making physical skill games. Two groups had the winners getting all the stones. The diversity seen seems to suggest that so long as the context for a design activity has reasonable potential for diversity then even with eleven groups of teens there will be little replication.

5.3 Conservation and Development of ideas within a group

In our second analysis, a more open approach was taken to ideas with each output from Stage 1 being examined for as many ideas as could be clearly and distinctly articulated. This was then used as a starting point for the analysis of future outputs. Figure 2 captures the emergence and conservation of ideas across the four design outputs produced by each group. The visualization includes four columns which (left to right) show the analysis of outputs from Stages 1, 2, 3 and 4 respectively.

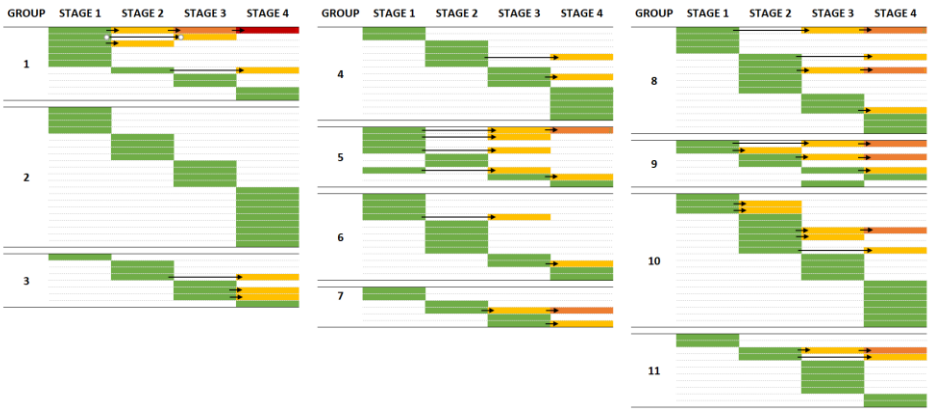

Figure 2: Conservation and Development of Ideas Across Design Outputs.

For each group in the visualization, each row represents an individual design idea identified in the analysis process; green blocks show the identification of a new design idea for that group. Where a design idea from a previous design output appeared in a later design output, this is colour-coded yellow if the design idea has appeared once previously, orange if it has appeared twice previously, and red if it had appeared three times previously. Clearly a red idea is one that has remained throughout. This idea would be describes as being as being very 'sticky'. Different groups behaved in different ways, for example, figure 2 shows that Group 2, carried no ideas from one design output to the next. From our visualization and analysis, we identify three trends in relation to idea emergence and conservation:

5.3.1High Conservation / Low Innovation.

For Groups 3, 5, 7 and 9 we can see that the majority (or sometimes all) of the ideas appearing in the fourth output were conserved from earlier design outputs, and also that these groups have an overall low number of emerging design ideas across all four design stages. We speculate that this may be attributed to a lack of creative input into the later stages and/or strong championing of early ideas within the group.

5.3.2Low Conservation / High Innovation.

In Groups 2, 4 and 10 we can see that many ideas are emerging across all of the design stages. For these groups the majority of design ideas in the fourth design stage are new and the number of these new ideas easily outweigh the number that were conserved. In these groups, we speculate that idea generation does not pose a challenge and the group are willing to discard old ideas in favour of new ones.

5.3.3Balanced.

The remaining four groups (1, 6, 8, 11) typically have equal numbers of conserved and new design ideas in the fourth design stage output and do not exhibit the strong tendencies from the previous two categories for either new ideas generation or conservation of old ideas.

6 Discussion

6.1 Diversity of Ideas and Multi-Group Design Studies

From the analysis of the Diversity of Ideas across groups there seems to be adequate justification for encouraging all 11 groups to participate in so far as there is not a large overlap in ideas across the groups. It appears that diversity increased as the scope of the design activity broadened and as the pupils had more

possibilities (when they could bring in mobile technology). This increase in diversity seemed to drop when the additional possibility of connectivity came in and it could be that this was to be expected as connectivity is an abstract concept that the less imaginative pupils may have struggled to fully interpret into game designs.

It is worth thinking about what 100% diversity, using this analysis, would mean. On the one hand, this might be a justification for having many groups working on a project, but it would bring with it its own difficulties for a design team in terms of what they would then do with the results. Similarly, diversity scores of less than 50% may suggest that a design is either over specified or that the design team may be engaging with too many participants. We recommend/ teams to consider diversity when reflecting on multi group design sessions.

6.2 Conservation of Ideas and Multi-Session Design Studies

Being able to see how ideas came and went, as visualized in figure 2, allows us to speculate on different group behaviours. As well as seeing how ideas move through the stages, the visualization lets us see quite graphically that some groups were simply more able to ideate than others. Whilst Group 2 clearly had lots of new ideas each time, Group 7 seemed to be short of ideas from beginning to end. The most creative groups (the ones with the most ideas) kept re-imagining solutions which may suggest that the leaving behind of ideas is an important activity to facilitate in co-design sessions. It may be that deliberately taking away earlier ideas may even be advantageous in some circumstances. This is counter to the idea of elaboration [25] but certainly more work needs to be done to determine when each variant is more appropriate.

In terms of ideas moving through stages and the meanings we can derive from knowing this, we can imagine a scenario where a team have five good ideas at the outset and then bring no new ideas through the next stages. In our own example here, that would probably imply that they failed to take into their designs any of the later props and chose to stay with a non-tech idea. In other cases, however, this may represent a successful outcome where the team had a great idea at the start of a series of workshops and stuck with it. It is again important for the design team to consider what might be optimal for their design situation. Contrariwise, when a team flick from one set of ideas to another, this may show either creativity or a lack of focus. Having many ideas and not building on any may not be a profitable use of the teens' time if nothing at the end of the activities has been developed enough to have value.

6.3 Critical Evaluation of Design Activities

Our own evaluation was assisted by the process of analysis and by examining the outputs. We were surprised, for example, that the diversity dropped by Stage 3 but on reflection we were able to realize that this could have been because we unwittingly narrowed the scope. When conducting design sessions such as this it is important that designers carefully consider the information that is given to the participants. In this case the understanding of the concept appears to have affected this stage of the process but designers also need to be careful not to stifle, or bias, the designs being produced. It was interesting, knowing the groups and having worked with them, to see their journeys mapped to the visualization in figure 2. Whilst we were aware that some groups were elaborating on earlier ideas; having seen where directions changed, but also where ideas came back, was enlightening. One group had struggled throughout the activity and eventually had very few ideas and this was evident in the visualization. However, what we hadn't realized at the time was how that group's activity was quite different from other groups.

We have learned from this work that the critical evaluation of design activities is necessary for us to learn from our practice but also to enable us to empower participants and maximize their engagement. The visualization in this paper was done after the four design sessions were completed but we do think there may be value in doing such a visualization part way through a design process as it could illuminate problems with either the design activities or with the participant teams.

7 Conclusion

We have explored the value of parallel incremental design sessions with teens in terms of the diversity and development of ideas generated. A visualization has been used to capture how ideas pass across from one session to the next. Looking at how teenagers develop ideas it transpired that the best designs came from those who had the most ideas overall. This work has allowed us to better understand the value of their participation in the study to highlight the worth in their involvement but has not directly looked at this value from the perspective of the teenagers involved. We offer the visualization as a tool for others to use in the IDC community. Future work will use this in other design studies and with other populations to validate the method in different contexts. It is hoped that further use with enable guidelines to be produced for the community to facilitate the evolution of design ideas through a multi session design process.

8 Selection and Participation of Children

The children who took part in this work were all selected by their school teachers to participate. They were fully informed as to the nature of their participation and each time they handed in designs they were told they had the right to not hand them in. The students were also given the right not to participate. No incentives were given.

Acknowledgements

The authors would like to thank the pupils and staff of Ribblesdale High School for their contribution to this work.

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