Designing a Digital Experience for Young Children with Developmental Disabilities

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Abstract. This paper reports on the development of a playful digital experience, Anim-action, designed for young children with developmental disabilities. This experience was built using the Stomp platform, a technology designed specifically to meet the needs of people with intellectual disability through facilitating whole body interaction. We provide detail on how knowledge gained from key stakeholders informed the design of the application and describe the design guidelines used in the development process. A study involving 13 young children with developmental disabilities was conducted to evaluate the extent to which Anim-action facilitates cognitive, social and physical activity. Results demonstrated that Anim-action effectively supports cognitive and physical activity. In particular, it promoted autonomy and encouraged problem solving and motor planning. Conversely, there were limitations in the system's ability to support social interaction, in particular, cooperation. Results have been analyzed to determine how design guidelines might be refined to address these limitations.

Keywords: Young children, developmental disability, interactive experience, design guidelines, evaluation, play and games.

1 Introduction

Increasingly, innovative technology is being utilized in early childhood settings and there is clear evidence that well designed systems have the potential to engage young children, respond to their developmental needs and stimulate learning through play [3]. However there is limited research focused on the design of new technology for children with developmental disabilities, especially within the early childhood years. Effective integration of playful technology into settings that include children with developmental disabilities is an ongoing challenge and our research is focused on addressing this issue. The research was guided by two research aims. Firstly, our objective is to identify the design requirements necessary to create playful interactive experiences that are meaningful and appropriate for young children with developmental disabilities. Our second aim involves understanding the extent to which the experience developed supports cognitive, social and physical play.

adfa, p. 1, 2011.

2 Background

Developmental disabilities can be defined as “a set of abilities and characteristics that vary from the norm in the limitations they impose on independent participation and acceptance in society” [4].There are a number of studies that specifically examine the use of educational games for children within developmental disabilities [1, 2, 6]. Research has demonstrated the effectiveness of computer games in supporting engagement [5], facilitating social skills [1] and providing opportunities to role play behaviors that are challenging in real social contexts [2]. However, a majority of the research in the field is focused on children aged between 7 and 14.

Our own previous research focused on the development of game-based interactions for adults with intellectual disability resulted in the development of the Stomp platform [8]. The floor-based system allows users to interact with digital environments by triggering pressure sensors embedded within a 2 × 3 meter floor mat. Interactive applications are projected onto the mat using a short throw projector. The platform effectively turns the floor into a large pressure sensitive computer screen. The system is designed so that actions such as stomping, stepping and sliding in Stomp are like stomping, stepping and sliding in the real world [8]. We use Stomp in our research as a means through which young children may engage in inclusive digital learning experiences.

3 Designing a Stomp Application for Children with Developmental Disabilities

In order to understand the requirements of an interactive experience for young children with developmental disabilities we involved teachers and support staff from an early childhood center that caters specifically for children with developmental disabilities. Initially, four informal meetings were undertaken to gain information on the types and nature of disabilities of the children who attended the school and to explore attitudes to technology designed to support children with developmental disabilities. From the initial meetings we established that the teachers felt it was appropriate to use the Stomp platform to create a playful experience for children aged between four and six years. Two individual semi-structured interviews and one focus group involving three teaching staff followed these initial meetings. These discussions lasted between 45 minutes and one hour and were designed to illicit specific information with respect to the design of an interactive experience for the children attending the centre. These discussions resulted in the development of the interactivity design goals that were used to guide the design of the new application.

General Interaction Goals: Interviews with teachers established that the interactive experience must not rely too heavily on a child’s social skills, as this is often one of the most impaired abilities of children attending the school. As concepts such as teamwork are relatively new to this age group, any collaboration must be simple. For the most part, interaction is between the teacher and student. Therefore methods that enable greater communication between these two parties are just as important as improving student-to-student social skills. Four specific design guidelines were developed as a result:

- G1: Interaction should be clearly defined and simple.
- G2: The experience should facilitate supervisor / teacher interaction with the student.
- G3: The experience should facilitate interactions between students.
- G4: Interaction should not rely on successful collaboration or teamwork from students.

Input: Motor skills of the children vary, and the range encompasses those mildly impaired to children who are heavily impaired. System input requiring gross motor skills must take into consideration the physical build of a child. Actions need to be constrained to the reach, jump and step distance of a five-six year old child. Often developmentally delayed children's hand eye co-ordination is limited, therefore input actions requiring reflexes or accuracy will need ample room and time. Reaction time and spatial awareness is often impaired and events requiring actions must allow for this and occur at a slower speed. Object motion should be slow and relatively predictable. We developed three design guidelines based on this information:

- I1: System input should only rely on simple fine and gross motor skills.
- I2: Design actions that allow ample room and time for participants to react.
- I3: Input rules and boundaries should be clear and intuitive.

Feedback: Directions need to be clear, discreet and repetitive to ensure the message is conveyed. Once an action or task is complete audio/visual feedback should be provided to ensure children comprehend that a goal has been achieved. When conveying messages or events visually, content must be modest in color and intensity. Over stimulation and confusion may result from an excessive range and intensity of colors, shapes and objects being visible on the screen space. Excessive noise or loud sudden sounds can disturb some children. Three specific design guidelines stem from this information:

- F1: Feedback should be clear and discreet.
- F2: All forms of feedback should not be excessive or loud.
- F3: Feedback should occur immediately after input from a child.

4 The Anim-Action Experience

Anim-action is a collaborative art experience playable on the Stomp interactive surface to maximize the advantages of using a system that allows for whole body interaction. Participants can work together or individually to create, color and draw animal characters that come to life. Three stages were included in the experience; these were designed to progress the participant from simple to more complex learning goals (see Fig. 1).

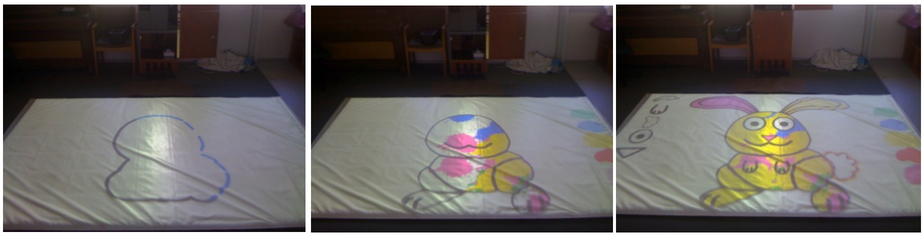

Fig. 1. Anim-Action Interactions – (from left to right) draw mode, color mode and detail mode

Each mode has been designed to incorporate the interactivity and goals identified in section 3. Stage one, draw mode, requires participants to start drawing the outline shape of their created animal character. The participant walks along the dashed outline of the shape, activating solid line pieces until the shape is a continuous solid outline. In color mode the participant may choose colors from a selection available from the side bar. Colors may be selected by simply stepping or jumping on them. Painting will occur when the child stands inside the animal outline area. Detail mode keeps the color bar on the side of the mat, but also introduces additional animal details as objects on the opposite side of the mat. Details, such as body parts and facial features, can be added by jumping or stepping on an object (e.g. eye) and then placing the body part on the animal. Correct positioning is indicated by a highlighted outline. Selecting from the color pallet either before or after object selection changes the color of these body parts. The Anim-action experience was designed to meet the interactivity design guidelines and educational goals in the following ways.

General Interaction: The space for social interaction is clearly defined and children are able to step anywhere on the mat without penalty (G1). Teachers are readily able to observe interactions and guide/instruct children as required (e.g., guiding a task, suggesting some cooperative activity) (G2). Stage 2 and 3 provide opportunities for children to engage in simple social interactions (e.g., in stage 2 one participant might select a color and the other paints, or both children might be involved in painting different areas of the shape (G3). While there are varied levels of social interaction from observing, through to advising and interacting (G3), interaction does not rely on any collaboration or teamwork (G4).

Input: The space for interaction takes up a large portion of the 3m x 2m floor mat and each interactive piece (e.g., line in draw mode, paint blob in color mode) provides a generous activation zone that is larger than a child's foot (I1, I2). The main objectives of the activities be can achieved through simple stepping motions (I1). The visual properties of the application ensure that input rules are simplified. For example, the dashed outline, as the only element on the mat initially, invites the participant step on that line to see what happens (I3). There is continuity from Stage 1 to Stage 2 as the outline shape remains the same. This allows the participant to work within the same area of the floor and follow similar rules of interaction (I3). A color in the color palette is already active when color mode starts. Consequently, a child can start painting without actively selecting a color (I3). Similarly, a body part choice is activated when detail mode becomes available (I3). No time constraints are enforced by the system (I2) and primary interactions occur within the boundary of the animal (I3).

Feedback: When in draw mode, the system responds to a child stepping on the outline of the shape by changing the dashed line to a solid line section and emitting a "click" sound effect (F1). During paint and detail mode, only one selection can be chosen at a time (e.g., a color blob from the paint palette, or a body part from the details menu) (F1). Upon selection of the color or body part in the system responds with visual and aural feedback and the chosen object remains highlighted when active (F3). A subtle glow effect is used to indicate the selection that is currently active (F2). During color mode, one foot step on the mat is represented as one individual paint splat (F1). Once a participant steps on any area within the shape outline, a paint splat effect is created (F3). To guide children towards shape selection in detail mode, an initial shape outline (e.g. eye) is highlighted on the animal's body (F1). When a shape piece has been correctly placed, feedback is given via a visual and audio cue (F3). Once this has occurred a new missing shape piece will be highlighted (F1). All visual and aural effects are designed to clearly depict an outcome, while at the same time being subtle in color and format so as not to over stimulate or distract children (F2). All system feedback is immediate (F3).

5 Anim-action Evaluation

Thirteen children, aged 5 and 6, participated in the evaluation of the Anim-action. Twelve boys and one girl from four different classes were involved. The study took place on six days during a two week period and study findings are based on observations of participants' engagement in the Anim-action experience. Each session lasted approximately 45 minutes and the observation method was based on existing teacher assessment schemes. The use of teachers to make assessments has been found to be highly effective in assessing the behavior of children with developmental disabilities [7].

Teaching staff observed each child and recorded the child's displayed behaviors on an observational checklist sheet. Observation items were divided into four categories: cognitive (five items); social divided into two sub-categories: communication (four items) and social interaction (four items); and gross motor physical skills (three items). Observed behaviors were scored based on the level of assistance required during interaction for each checklist item. For a particular skill, such as color matching (cognitive), a child would be given a score between zero and five. The scoring system is as follows: 0 – no behavior exhibited; 1 – child did not initiate activity and at least two types of prompts were provided (e.g., verbal and physical); 2 – child did not initiate activity and one type of prompt was provided; 3 – child initiated activity and at least two types of prompts were provided; 4 – child initiated activity and one type of prompt was provided; 5 – child completed activity independent of support.

6 Findings

Analysis of data was performed to determine what kinds of interactions children were engaged in while playing Anim-action. We examined independent behavior, as defined as a child receiving a score of 5 (independent) or 4 (limited prompting) for a particular item. Similarly, dependent behavior is defined as a child receiving a score of 1 (dependent) or 2 (partially dependent). Results indicate that most children were able to engage independently in the cognitive activities of color matching (85%), shape matching (85%), problem solving (77%), task focus (85%) and body awareness (85%). Fig. 2 details the results for cognitive engagement across the five items measured. Similarly, most children were able to independently engage in physical activities while playing Anim-action (Fig. 3). They independently exhibited concentration on movement (85%), balance (100%) and motor planning (92%).

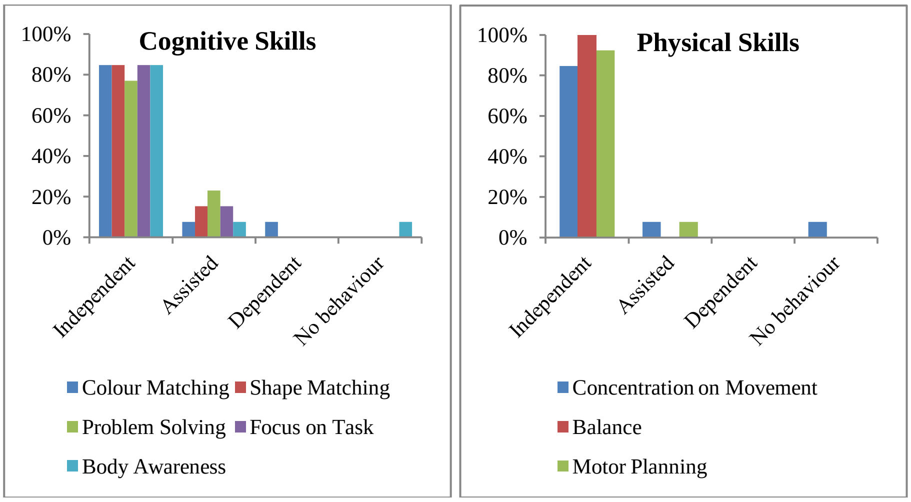

Fig. 2. Children's engagement in cognitive and physical activity.

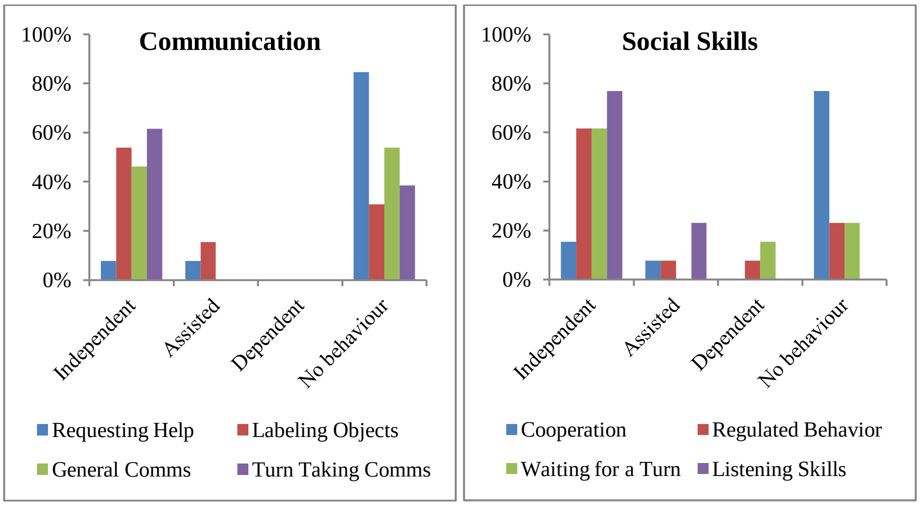

Fig. 3. Children's engagement in social activity.

Scores for independent activity were considerably lower in the communication and social interaction categories. In both areas a more bi-modal distribution is evident, such that children were either relatively independent in their behavior, or no behavior was exhibited at all (see Fig. 3). Investigation of communication skills engaged in while playing Anim-action shows that requests for help were limited, with 11 of the 13 children never requesting help. There was slightly more evidence of independent labeling of objects (54%), turn-taking communication (62%) and general communication (46%). While results show that cooperation was limited, with 10 of the 13 children exhibiting no cooperative behavior, children were observed engaging in other independent social activity: 62% were able to independently regulate their behavior and 62% were able to independently wait for a turn and all children listened for direction (either independently or with assistance).

7 Discussion and Conclusion

Results indicate that Anim-action was effective in promoting physical and cognitive engagement for young children with developmental disabilities. Of particular note was the evidence of independent problem solving and motor planning that occurs during the Anim-action experience. The staged approach to introducing complexity in both physical and cognitive activity through a carefully considered design may explain this result. Children were introduced to simple, structured gross motor activity (i.e. line following), before being required to move from one part of the play space to another in order to achieve their goals. The experience implicitly enforced simple interaction rules and while there was no negative feedback, a lack of responsiveness for incorrect activity may have encouraged children to focus on moving their bodies to achieve the desired outcome. Similarly, problem solving was introduced gradually and visual cues (e.g. the outline of a body part) provided scaffolding for the problem solving process. Immediate visual feedback allowed children to assess the effectiveness of their actions. Children are immersed in planning and problem solving activity.

These results suggest that children were less engaged in social interaction. The system was designed so that children could work effectively autonomously and independently. There was no explicit requirement for social interaction, with G4 explicitly aimed at ensuring that interactions did not rely on collaboration. In light of the findings it may be necessary to rethink criterion G4 and how such a requirement is implemented. For example, while cooperation might not be necessary, more encouragement of, and reward for, engagement in shared experiences could be included. These findings also demonstrate that design decisions related to criteria G2 and G3 need to be reconsidered. It is perhaps necessary to consider an implementation that includes more systematic and overt mechanisms for teacher-student and student-student interactions.

The automated within Anim-Action experience may also be partly responsible for this finding, with the system providing prompt cues to guide a child’s interaction. This automation may result in children not needing to ask for help. It also appears that the immersive nature of the digital experience results in a reduction in cooperative interaction. At the same time, it may be these automated and immersive qualities that have led to an increase in independent problem solving and motor planning. This tension between autonomy and immersion, on one hand, and social connectedness on the other, needs to be acknowledged in the development of new digital experiences for learning.

The results indicate that Anim-action is effective in supporting cognitive and physical engagement. Children's ability to work autonomously and not ask for help can be seen as positive. However, it needs to be acknowledged that the current study indicates that the experience was not as effective in facilitating social behavior. For children with developmental disability, where interaction is primarily with teachers and support staff, social interaction is a key aspect of early intervention programs. It would appear that the design of a digital system needs to be carefully considered in light of our findings to ensure that mechanisms are built in that better support collaborative behavior. It may also be that such digital experiences are most effective when they focus on one aspect of children's development and not another with experiences that attempt to simultaneously achieve all possible development goals ultimately being less successful. Future research will also explore the extent to which this pattern of results extends to other Stomp experiences and comparable non-digital activities.

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9 References

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