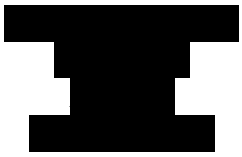
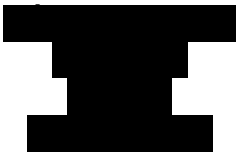
Comparing Digital and Non-digital Games Designed for Young Children with Developmental Disabilities





ABSTRACT

This paper reports on a comparative study designed to examine the behavioral differences of children with developmental disabilities as they engage with educational games. Of particular interest are the differences in cognitive, communicative, social and physical activity afforded by a digital game in contrast to a non-digital game. A within-subject study involving 13 young children with developmental disabilities demonstrated that the digital game facilitated autonomy and encouraged problem solving and motor planning significantly more effectively than the non-digital game. However the non-digital game performed better at involving children in social interactions.

Author Keywords

Computer games; developmental disability; young children; evaluation.

ACM Classification Keywords

K8.0. General: Games; K.4.2. Social Issues: Handicapped persons/special needs.

General Terms

Human Factors; Measurement.

INTRODUCTION

Games and play are an essential aspect of early childhood education and while children with developmental disabilities are generally cognitively delayed, the progression through stages of play in early childhood remains unchanged [6]. Despite research that has examined the learning benefits associated with digital games across a range of curriculum areas and for a range of children, there is limited research focused on the effectiveness of serious games for children with developmental delays, especially within the early childhood years.

This paper reports on a study designed to evaluate a new digital experience, designed specifically for young children with development disabilities in comparison to a traditional, non-digital learning experience. Of particular interest are the differences in cognitive, communicative, social and physical activity afforded by the digital system in contrast to the traditional approach. Our study used a within-subject design and involved 13 young (five and six year old) children with developmental disabilities engaged in two experiences: a digital game and a non-digital game. Results showed that the digital game facilitated autonomy and encouraged problem solving and motor planning significantly more than the traditional game. However the non-digital game performed better at involving children in social behavior.

CHI'13, April 27 – May 2, 2013, Paris, France.

BACKGROUND

Our research in the design and development of educational technology is focused on children with developmental disabilities. Developmental disabilities include sensory, communicative and intellectual impairments, autism spectrum disorder (ASD), attention and hyperactive disorders (e.g. ADHD), Down syndrome and cerebral palsy [1]. It is common to find an individual who has multiple disorders which share similar attributes such as impaired cognitive, communicative, motor, and social behaviors [9].

Digital Games and Developmental Disabilities

Play and games form an essential part of early childhood education. Practice play, symbolic play and games with rules are all beneficial to a child's development [7]. Our research focuses particularly on games with rules; play that is structured by rules and objectives. We are interested in better understanding the potential for digital games to support children with a range of developmental disabilities.

Recent research has found that computer games constitute a playful context through which children with disabilities can identify with fantasy figures on a screen, get motivation for difficult physical actions and simultaneously receive training [12]. The sensory motor abilities of children with Down syndrome have been found to improve through interventions involving virtual reality using Wii gaming technology [13]. Evidence also suggests that children with ADHD are able to manifest superior executive function performance, as measured by decreased error making and increased on-task activity, during videogame play than in other contexts [11]. Research focused on ASD has demonstrated the effectiveness of computer games in supporting engagement [10], providing a focus for peer discussion [2] and providing opportunities to role play behaviors that are challenging in real social contexts [3].

Design is an important consideration for games that support children with developmental disabilities. Developmental issues that are important to consider include deficiencies in communication skills, certain information biases, difficulties with visual perception and search tasks, the importance of concrete output and issues related to fine and gross motor skills [4].

DIGITAL SYSTEM DESIGN AND IMPLEMENTATION

The Stomp hardware platform, a system initially designed for adults with intellectual disability [5], was utilized for the development of the digital gaming experience for young children with developmental disabilities. This floor-based system allows users to interact with digital environments by triggering pressure sensors embedded within a 2 × 3 meter floor mat. Interactive applications can be projected onto the mat using a short throw projector. The platform effectively turns the floor into a large pressure sensitive computer screen. Users interact with experiences by stomping, pressing, jumping and sliding. The software application is stored on a computer within the system.

In order to understand the requirements of an interactive game for young children with developmental disabilities we engaged in a user-centered design process involving teachers, support staff and children from an early childhood center that caters specifically for children with developmental disabilities. The process involved informal meetings, interviews, a focus group and classroom observations. The Stomp Anim-Action Game was based on the outcome from this process.

The Anim-Action Game

Anim-Action is a collaborative art game specifically designed for pre-school aged children between four and six years of age. Children playing Anim-Action create, color and draw animal characters that come to life. There are three key stages within Anim-Action.

Stage one, **draw mode**, requires players to start drawing the outline shape of their character (see Figure 1). The player is required to walk along the outline of the shape, activating solid line pieces until the shape is a continuous solid outline. Once a character has been drawn, the second stage, **color mode**, starts (see Figure 1). In color mode the player may choose colors from a selection available from the side bar. Colors may be selected by simply jumping on them. When the child stands inside the animal outline area painting occurs. The aim is to step on all areas until the animal is completely colored. Stage 3, **detail mode**, keeps the color bar on the side, but also introduces additional animal details as objects on the right side of the mat (see Figure 1). Details can be added by jumping or stepping on an object (e.g. eye) and then positioning the object where is should be placed on the animal. Correct positioning is indicated by a highlighted dashed outline. Selecting from the color pallet either before or after object selection may change the color of these objects. Once all the details have been added, the character is complete and it comes to life via a short animation.

Figure 1: The three Stages of the Anim-Action game. From top to bottom: draw mode, color mode and detail mode.

EXPERIMENTAL DESIGN

A non-digital classroom game experience was developed to use as a comparison to the Anim-Action game. Like Anim-Action, this game included three stages, the first where children used flat wooden shapes to create animal outlines, the second where they used colorful craft materials to decorate the animal, and the third stage involving the use of preschool resources such as sticks, bats and cones to create animal body parts.

Two conditions were used for the comparative study: the Anim-Action game condition and the non-digital game condition using the existing preschool resources. A within-subject design was used where participants from the early childhood unit of a government run special school took part in each of the conditions.

Participants

Thirteen children, aged between 5 and 6, participated in the study. Twelve boys and one girl from four different classes were involved. Five students participated from one class, three students from two classes and two students from the other class. Due to ethical constraints, it was not possible to gather information on specific conditions. However

disabilities of the children included Autistic spectrum disorder (ASD), Cerebral Palsy, Down syndrome, Global Developmental Delay, speech language impairment and more generalized intellectual inabilities.

Procedure

The study was integrated into the normal classroom timetable, with each classroom group engaging in the study separately. The study took place over six days during two week period. All children participated in the non-digital game over three days in the first week and the Anim-Action game over three days in the second week. Unfortunately, due to logistic constrains involved in managing the children and activities in this complex environment, it was not possible to vary the order of the two study conditions.

Study findings are based on observations of participants' engagement in both games. The study observations were conducted within class groups. Each class group observation session lasted approximately 45 minutes with between two and five children being observed. The observation method was based on teacher assessment schemes found to be highly effective in assessing the behavior of children with developmental disabilities [8]. One researcher and two teacher experts were involved in observing children's interactions with the game. During the observation period, the researcher took notes while the selected expert teaching staff observed each child and recorded the child's displayed behaviors on an observational checklist sheet.

Measures

The checklist developed for the study is based on existing observational checklists used by teachers at the school. Observation items were divided into four categories: cognitive (five items), communication (five items), gross motor (three items) and social (four items). Cognitive skills included color and shape matching, problem solving, focus and concentration. Observation items included in the communication category were requesting help, labeling objects, general communication, listening to directions and turn taking in communication. Gross motor skills included body awareness, balance and motor planning. Social skill observation items were cooperation, regulated behavior, waiting for a turn and asking for a turn.

Observed behaviors were scored based on the level of assistance required during interaction for each checklist item. Coding of the data involved scoring observations based on the level of independence exhibited by children as they completed the non-digital and Anim-Action game. For a particular skill, such as color matching, a child would be given a score between zero and five. The scoring system is as follows: no behavior exhibited – 0; child did not initiate activity and required at least two types of prompts (for example, verbal and physical) – 1; child did not initiate activity and one type of prompt was required – 2; child initiated activity and required at least two types of prompts – 3; child initiated activity and one type of prompt was required – 4; children completed activity independent of teacher support – 5.

FINDINGS

Quantitative analysis was performed to determine if there were any significant differences in the behavior of children when playing a non-digital and digital game. Paired-samples *t*-tests were conducted to compare children's behaviors in the Anim-Action game and non-digital game conditions. Analysis was undertaken for each observation item as well as on the average scores in the cognitive, communication, gross motor and social skill categories.

There were no significant differences in the average scores for cognitive behavior, communication or gross motor skill categories within the Anim-Action game and non-digital game conditions. However there was a significant difference ($\alpha < 0.1$) in the scores for a single item in each of the cognitive, communication and gross motor categories. The results in Table 1 suggest that there was an increased incidence of asking for help in the non-digital game condition, and that participants were more likely to engage in problem solving and motor planning in the digital environment.

Category	Condition	*M*	*SD*	*t*(12)	*p*
Problem solving	Digital	4.15	0.8	2.01	0.07
	Non-digital	3.62	1.26		
Asking for help	Digital	0.62	1.56	-2.01	0.07
	Non-digital	1.84	2.3		
Motor planning	Digital	4.85	0.55	2.21	0.05
	Non-digital	4.31	0.95		

Table 1: *t*-Test results for significant items in the cognitive, communication and gross motor categories.

Social Skill Behaviors

There was a significant difference in the average scores for social skill observations within the Anim-Action game (M=2.62, SD=1.44) and non-digital game (M=4, SD=1.35) conditions, $t(12)$=-3.524, p=0.004. These results suggest that type of game experience does have an effect on social interaction. Specifically, our results imply that when players engage with the digital game, the amount of social interaction decreases. Table 2 provides details about the specific items which were shown to vary significantly ($\alpha < 0.1$) within the social skills category.

Results suggest that social interaction differences primarily relate to cooperative behavior, but are also influenced by players engaging in regulating behavior and waiting for a turn in the non-digital game. The researcher observed that participants were more immersed in the digital experience than the non-digital experience. This resulted in limited interaction with others present during the activity, including

teachers and support staff. There were occasions where children ignored or failed to acknowledge those around them.

Category	Condition	*M*	*SD*	*t*(12)	*p*
Regulated behavior	Digital	3.31	2.21	-1.97	0.07
	Non-digital	4.46	1.2		
Cooperative behavior	Digital	1	1.96	-3.99	0.00
	Non-digital	4.15	1.67		
Waiting for a turn	Digital	3.31	2.18	-1.9	0.08
	Non-digital	4.46	1.39		

Table 2: *t*-Test results for significant items in the social behavior category.

DISCUSSION AND CONCLUSION

Results clearly indicate that young children with developmental disabilities are more likely to engage in social behavior while engaged in a non-digital game experience. This traditional experience appears to be better at providing opportunities for children to cooperate and regulate their behavior. The automated nature of activities in the Anim-Action game may be partly responsible for this finding, with the system providing cues with respect to when children should begin and end engagement and move to the next stage. This automation may result in children asking for help less often in the digital condition. System guidance makes such questions unnecessary.

It also appears that the immersive nature of the Anim-Action game results in a reduction in cooperative interaction. At the same time, it may be this immersive quality that has led to an increase in independent problem solving and motor planning. This tension between immersion, on one hand, and social connectedness on the other, needs to be acknowledged in the development of new digital games for learning.

The results indicate that neither gaming condition is superior to the other in providing a *whole child* learning experience for young children with developmental disabilities. Our findings demonstrate children engage in some elements of cognitive, communicative and physical behavior at a higher level within the digital condition. Children's ability to work autonomously and not ask for help can also be seen as positive. However, it needs to be acknowledged that the current study indicates that non-digital gaming was more 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.

ACKNOWLEDGMENTS

Removed for blind review.

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