**Effects of Tablet-Based Educational Games on Numerical Knowledge**

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School districts across the country have increasingly implemented new policies and programs introducing more technology into the classroom. Many schools have started providing tablets and laptop computers to all students and encouraging the use of these relatively novel devices throughout the educational experience. Questions that educators and parents will have to address are "Are we confident that tablets provide an improved educational experience compared to traditional teaching methods?" and "Will the use of expensive tablet computers in education continue to drive a wedge between the opportunities for academic achievement for the rich and the poor?" Furthermore, what role in the educational process should technologically advanced devices play and when, if ever, is too young for a child to use a tablet computer.

**Literature Review**

In discussions with early childhood education specialists, it has become clear that "the screen" can seem like an evil whose influence on a child's development must be limited (Kaul, 2015; Loven, 2015). The claim made is that during early childhood development, before the age of five, the primary role of the child is learning to socialize with peers and adults. They argue that while the tablet may be entertaining for the child or a helpful distraction to enable the parent or provider a measure of free time it does not provide the same benefits to the child's cognitive development as direct personal interaction. The American Academy of Pediatrics has recommended that "television and other entertainment media should be avoided for infants and children under age 2." However, those same guidelines also note that for slightly older children, controlled access to technology can promote media literacy (American Academy of Pediatrics, 2012).

The claim that children do not gain any benefit from "the screen" is dubious. For example, experiments comparing children who reportedly watched educational television programming such as Sesame Street have found that increased viewing between the ages of 3 and 4 was significantly correlated with improved vocabulary two years later (Rice, Huston, Truglio, & Wright, 1990). The authors hypothesized that this improvement was due to the high degree of attention that children devoted to the television while watching and the educational focus and repetition of the material presented in the program.

In another study of children's habits regarding Sesame Street viewing and attention, experimenters noted that younger children were more drawn to toys and connecting with their mothers while older children were able to pay attention to the television for much greater periods of time (Anderson & Levin, 1976). The fact that young children seem to intuitively seek physical and social interaction should comfort those who fear that children placed in front of televisions are doomed to live a life totally lacking in interpersonal interaction. Both of these findings seem to provide support for the positive benefits to cognitive development, both in semantic knowledge and attention, that one sided interaction between a child and a technological screen can provide.

The screens has been shown to provide some extremely positive effects on social behavior for preschool aged children. In one study, children's interactions were observed before and after one week of exposure to either Sesame Street or Mister Rogers' Neighborhood. The authors' surprising findings showed that children's frequency of giving positive reinforcement to peers increased significantly after the exposure. Interestingly, there was a difference in the tendency of the programming to improve the children's behavior. Whereas Sesame Street only improved the interactions of children who had initially scored low during the baseline observation, Mister Rogers' Neighborhood was successful at increasing positive reinforcement and social contact among all children (Coates, Pusser, & Goodman, 1976). Children are clearly able to gain significant social and behavioral skills from individual interaction with the television perhaps assuaging some of parents' guilt or fear regarding children's screen use and encouraging use of child-focused television programming to boost children's self-confidence and self-esteem.

In a recent British study of approximately 11,000 children, researchers found that watching television for greater than three hours predicted a slight increase in behavioral conduct problems. They did not specify the kind of television that the children were watching. The study authors also found that children's interactions with electronic games did not correlate with any ill effects (Parkes, Sweeting, Wight, & Henderson, 2013). This provides additional evidence that children will not experience behavioral or socialization harm as a result of interaction with tablet computers and educational games or apps.

Making education more entertaining for young children can lead to more equal opportunity and greater academic success in the future and thus it is imperative that we study ways of increasing learning in early childhood (Ramani & Siegler, 2011). It is important to discuss the varying impact that interaction with technology will have on children of different family income backgrounds so that public policy and funding decisions can be made to provide the most benefit to the public. Tablet computers are expensive and there is a risk that any benefits that they could provide to child development will be solely enjoyed by those parents or schools that can afford them. As a child's family's income is a huge predictor of that child's future achievement, there is a risk of increasing social division between the "haves" and the "have-nots" (Dahl et al., 2005).

Television has been a powerful educational aide to children across economic divisions. The vocabulary study discussed above found that the attention and vocabulary benefits of Sesame Street were experienced by children across a wide variety of backgrounds. The authors also found that by 1990, Sesame Street was no longer, "viewed more often by economically advantaged than disadvantaged children," so the benefits to children crossed class divisions (Rice et al., 1990). As school districts begin to purchase tablets for use by all students, there is room for increased opportunity for all children within the district to experience all of the educational benefits of access to technology leading to a higher degree of educational advancement by the residents of the area. However, even if this policy serves to improve equal access to opportunity in high and middle income areas, there is a severe risk that poorer districts will increasingly fall behind in regards to educational opportunity.

In a recent review of a one laptop one student initiative for fourth and fifth graders in a California school district, researchers found that only students from at-risk backgrounds, which they defined as Hispanics and low-income households, made significant gains in English language skills (Zheng, Warschauer, & Farkas, 2013). This points to technology's potential as a great equalizer. The groups that benefited the most from the laptop program were also the group that were least likely to otherwise have access to the internet or other modern computing device. This points to a probable finding of the proposed study; technology is able to improve learning, but only to a point.

Going back to the study of educational television programming, the authors found diminishing returns on the benefits of increased exposure to the programming in both time spent per day/week measurements as well as with age (Rice et al., 1990). Together, these findings suggest that tablets are likely to provide some educational benefit. However, much like television, are likely to have diminishing returns.

Parents and educators want only the best for their children and thus will continue to search for any method or philosophy that will provide improved future benefit. However, history provides a shining example of technology's failure to provide a silver bullet that revolutionizes education for the better. Microsoft's PowerPoint software was introduced in 1990 and was initially much welcomed for its ease of use and relative simplicity. Today, there is considerable controversy about the effectiveness of PowerPoint as a presentation tool. In a study comparing PowerPoint's effectiveness to the traditional lecture style, university students retained 15% less material from the PowerPoint assisted presentation. However, and with vital implications to the proposed study, they also strongly preferred the PowerPoint presentation to the traditional lecture format (Savoy, Proctor, & Salvendy, 2009). This raises an important question, if the goal of a daycare provider or parent regarding early childhood education is primarily focused on building a thirst for learning than on specific achievements, then shouldn't educational technology be used if it encourages the child to enjoy learning more than the alternative?

There is anecdotal and scholarly evidence of very young children intuitively understanding how to use the touch screen of a tablet computer to interact with the device as an extension of their regular environment (Couse & Chen, 2010; Matthews & Jessel, 1993). Children are able to easily navigate the touch interfaces of tablet devices, rapidly becoming even more comfortable with the new technology than their parents. Because of their small size and weight, as well as the fast response to input, tablets are well suited for children to interact with as a part of their environment. Ergonomic analysis of children using tablets have found that while using traditional computers, children tended to have poor posture, leading to spinal alignment issues, and poor shoulder position. However, they noted that the position assumed when using tablets was similar to that that children assumed while playing with paper (Straker et al., 2008). Thus, tablets could hopefully provide many of the benefits that a computer can without the ergonomic issues.

During the past decade, tablets have become nearly ubiquitous. Recent surveys predict that nearly 200 million devices will be sold in 2015 alone (Gartner, 2015). It is difficult to argue that a child who lacks experience with tablet computers by the age of 5 will somehow be destined to a life of relative technological illiteracy compared to their more-experienced peers. The more significant discussion must be related to whether a tablet is an effective educational tool.

**Participants**

To study the effects of tablet computers and educational opportunity, the proposed study would require recruiting preschool aged participants from a wide variety of cultural, social, and ethnic backgrounds. It is important that the children represent the range of educational attainment achieved by preschoolers. Additionally, they must have a wide variety of experiences interacting with technology.

Ideally, participants with little to no experience with tablet computers could be recruited from both preschools in poor, urban areas where economics is the limiting factor on technology, and groups with stronger cultural aversions to children using computers where the choice not to introduce children to tablet computers is voluntary. It will be important to note the participants' experience with technology. Children should also be recruited from a range of geographic regions and countries.

Because children are expected to be able to reliably count up to ten objects[[1]](#footnote-1) by the time they enter kindergarten at approximately age five and the experiment will require testing the children on a range of simple mathematics questions, the ideal age range of the children will be between the ages of four and a half and five years.

**Method**

Participants will be assigned into one of ten conditions. The conditions are as follows: All combinations of {(physical or electronic) practice, (physical or electronic) testing, (limited or unlimited time} plus electronic testing control condition plus physical testing control condition . There will be a pilot study determining the possibility of using an auditory testing condition for all groups. This would reduce the number of conditions to five (four experimental combinations plus one control), which is much more reasonable.

The experiment will take place over the course of one five day week. On Monday morning, researchers will test the children's base level of mathematical reasoning skills by asking them to answer ten randomly selected addition questions drawn from a pool of all forty-five addition permutations from one to five (1+1, 1+2, ... 5+4,5+5). The number range is chosen because the max sum equals ten and children entering kindergarten are not expected to have more than a rough familiarity with numbers larger than ten.

The testing process will be carried out in the manner dictated by the experimental condition. In electronic testing, the test will be administered via a simple iPad application. For physical testing, the child will be expected to choose the correct number from a pile of number flashcards while the stimulus will be in flashcard form. For auditory testing, an adult will ask the child the addition question and expect a verbal response, prompting if some other response, for example raising some number of fingers, is given. During all testing conditions, no attempt should be made to encourage or discourage any self-prompted strategies such as counting on fingers or drawing on the screen or table.

After the initial testing is complete, participants in the experimental conditions will be given time to play a matching game during the weekday afternoons for the remaining days in the week. The practice stimuli consist of a matching game where the participant is directed to flip over two cards and if they match, they are removed from the board. On Monday afternoon, the cards consist of the numbers one through five in one color, red, for a total of 10 cards. On Tuesday, green copies of the numbers one through five will be added, bringing the total number of cards to 20. On Wednesday, the deck will be replaced with yellow and blue cards for the numbers six through ten, so the deck will consist of 20 cards. On Thursday, the two decks will be combined and the total number of cards will increase to 40.

Depending on the experimental condition, either the child will be allowed to play the game for ten minutes, or as long as they want. Remember, that before entering kindergarten, children should be able to attend to an interesting activity for fifteen minutes (Kaul, 2015; Loven, 2015). Additionally, there should be some adult who is able to help the child with any technical issues or in shuffling cards if requested, however the adult should not attempt to do the activity for the child. For children in the physical condition, the stimuli will take to form of flashcards with the stimuli on one side and a simple uniform pattern on the other side. Participants in the electronic condition will be given an iPad preloaded with the game prepared with the appropriate setting.

On Friday afternoon, all participants will be retested in the same manner as the initial testing process. However, the number of questions should be increased to include fifteen questions randomly drawn from the question pool.

One possible issue with this methodology consists of the week based time frame. It is possible that any findings could be swayed as a result of the natural variances in cognition as a result of the schedule of the week. Perhaps, children are more rested after the weekend or are more primed for critical thinking after a week of preschool. Hopefully any effect from this compounding factor will be minimized by testing the control condition children both at the start and end of the week.

**Possible Results**

There are a number of possible results that this study might turn up and any conclusions about the impact of these results must be considered based on the goals of the activity. Earlier, we discussed a philosophy that preschool aged children should develop a love of learning. In this kind of atmosphere, study results showing that children prefer to play the matching game on the tablet for significantly longer that using the physical cards would support use of the tablet computer for educational activities regardless of how the addition performance varied between conditions. Similarly, if the goal of preschool is giving young children a strong knowledge basis for greater academic growth in elementary school and beyond, then the condition that leads to the greatest improvement in numerical knowledge should be recommended.

On a social progress basis, it is possible that children who would otherwise not have access to much technology will experience greater improvement than their more technologically experienced peers. This kind of result would encourage increased funding to preschools in poorer areas by state and federal funding agencies in the hope that lack of financial means would not prevent any child of reaching his or her full potential.

These descriptions of conclusions to draw have focused on the case where the electronic condition provided more improvement than the physical or control conditions. Obviously, this is not a certainty. In the other cases, the opposite conclusions can be drawn about avoiding tablet use among young children or discouraging educational groups from wasting money on expensive electronics that could be put to better use by purchasing physical games for the children to interact with.

**Conclusions**

Throughout this presentation, I have avoided discussing the behavioral or interpersonal impact of tablet computers. Educators have generally felt that children do not receive the same benefit from online interaction in a social network as a one on one presence with another person (Kaul, 2015; Loven, 2015). The study of viewers of Mister Rogers' Neighborhood seems to shed some doubt on this premise's more extreme interpretations. In observations of children at the Northfield Daycare, I found that children tended to alternate between group and individual activities. Electronic or physical educational games would ideally occupy the child's individual time and still enable children to receive experience interacting with peers in a socially healthy manner. The Vygotskian view would argue that tablet computers could provide some degree of scaffolding of children's knowledge development (Galotti, 2011). Observations of the participants could provide insight about the mental organization of the preschoolers. Researchers could track the manner in which the children physically or digitally manipulate the cards to aid in designing more engaging or effective educational games.

Tablets are a technology that has entered our social fabric to stay. We have an obligation to find a way to apply the benefits of the medium to benefit the developmental experience of children. As another tool for children to develop attention, reasoning, motor control, and many other cognitive processes, tablets will play a valuable role in childhood cognitive development.

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1. via the Northfield Public Schools "Child-At-A-Glance" handout provided by Mary Loven during class discussion on March 9, 2015 [↑](#footnote-ref-1)