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The Differences in STEM Feelings and Interest Between Boys and Girls

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ABSTRACT

Children are exposed to many areas of interest and careers through accessible media and technological devices. Research has shown that STEM careers are lacking in female representation. According to the National Science Foundation, women only represented 28% of individuals in science and engineering occupations in 2010 (NSF 2014). Exposure to STEM careers in early childhood may be an underlying cause of this underrepresentation; thus considering young children's feelings and interest in STEM is important for nurturing students to enter STEM fields. Children between ages 3.61 to 7.21 years ($N = 79$) were asked about their interests in STEM activities and feelings about a STEM task before and after playing a STEM application. Children reported decreased levels of STEM interest from pretest to posttest, whereas children's self-efficacy for a STEM activity did not significantly differ from pretest to posttest. The results suggest that short-term exposure to a STEM application did not increase children's STEM interest and self-efficacy toward STEM, as measured by children's verbal report.

Keywords: STEM diversity, Feelings, Self-Efficacy, Interest, Children, STEM differences

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INTRODUCTION

In the 2014 National Science Foundation's (NSF) Science and Engineering Indicators report, American society's negligence to nurture girls' interests in STEM was considered as one of the possible underlying causes of lesser female representation in Science, Technology, Engineering, and Mathematics (STEM) fields (National Science Board, 2014). Understanding early childhood experiences that influence gender differences in feelings and interests toward STEM can bring to light this inequality and contribute to understanding how to increase female representation.

A factor that has been found to have one of the strongest influences on children's feelings and interests in STEM is their exposure to or experiences with STEM (Meluso, Zheng, Spires, & Lester, 2012). Some children have positive feelings while others have negative feelings toward STEM (Cvencek, Meltzoff, & Greenwald, 2011). Researchers have posited that girls may experience lack of positive feelings toward STEM, which may result in girls' negative perception of STEM (Buck, Cook, Quigley, Eastwood, & Lucas, 2009). Moreover, in order to maintain and promote high interest in STEM, children must have a sense of connection with their envisioned careers (Kleinfeld, 2001). As girls' feelings toward STEM become well rooted and solidified, their interests may also increase (Master, Cheryan, & Meltzoff, 2016). Prior research has suggested that it is important to discover the ways in which girls can have positive feelings and interests in STEM-related activities.

Given the considerable amount of time young children spend with media (Richert et al., 2011), young children's feelings and interest toward STEM could be supported with the use of and exposure to technology and media. Some research has suggested that digital games are able to help children make analogies between the game and the real world so that they can better understand real world concepts. For example, Gros (2007) found that both male and female students who were given games to supplement the material taught in school could relate and connect concepts introduced in the game to lessons taught in class. A drawback from using the games was that students required a large amount of time to absorb the content from the game, guidance, and reassuring support from teachers for game instructions and higher transference of learning.

In a study with secondary school students, Miller et al. (2011) found children significantly gained content knowledge in STEM. Miller et al. (2011) selected children and randomly assigned them to play one of three different cases of Crime Scene Investigation. The data revealed that previous experience with web-based forensic science games was significantly related to performance on the pre- and post-exposure content knowledge tests (Miller et al., 2011). It could be that the forensic science games were straightforward and children had no difficulty learning the game. The current study uses a STEM task that is more challenging for children, so prior exposure to STEM concepts may be helpful in solving the activity. In addition, Miller et al. (2011) reported that participants who did not find the science games challenging were likely to learn more from the games than other participants who did find the games challenging. Participants' motivation to fulfill a STEM career was also directly proportional to their satisfaction of the game (Gros, 2007).

To provide children with positive feelings about STEM activities, it is important to understand conditions that help children to feel secure about their interests, experiences, ideas, and emotional responses to STEM. Exposure to STEM tablet games may increase children's feelings and interest toward STEM, and may provide more supportive data of media usage as an influential component in increasing children's feelings and interests in STEM (Meluso, et al. 2012). However, little research has been conducted to document the feelings about and interest in STEM in young children between ages 3 to 8. Further, prior studies have not focused on the comparison between males' and females' feelings and interests toward STEM after some exposure to STEM games (Yazilitas, Svensson, Vries, & Saharso, 2013). The current study examined the effects of children's exposure to STEM concepts and their performance on STEM tasks without additional guidance or feedback as in Gros (2007) to prevent teaching children the correct solution. Rather, the study was designed towards the interest of allowing participants to elicit their interests and feelings for certain STEM concepts.

The aim of the current study is to understand children's feelings and interest toward STEM and the transfer of learning from an interactive digital game to a real-world problem. Participants played an iPad game that was designed to teach a STEM concept and were asked to use that knowledge to complete a real-world task involving similar materials presented in the game. The study measured children's exposure to STEM using open-ended questions, children's pre and post-task reported feelings and interests toward STEM, and children's solutions to a game reported before and after playing the STEM game. Children were also tested to measure if they were able to make analogical connections between the items presented in the game and the tools used to solve the real-world STEM task. With exposure to the STEM game, children may be able to perform better on the real-world task and have higher feelings and interests toward STEM.

Research Questions

In order to understand children's feelings and interest toward STEM, the current study aimed to answer several research questions: Does an increase in liking the STEM game correlate to greater understanding of the iPad game? Does more previous STEM exposure relate to higher self-efficacy in the STEM task? Does STEM exposure relate to solving the STEM task? Does more exposure to STEM affect boys' and girls' interests toward STEM activities?

METHODS

Participants

Participants were 79 children between ages 3.61 to 7.21 years ($M = 5.50$, SD = 0.79) with 51.9% boys (40.1% girls), and 49.4% White (30.4% Multi-Ethnic, 13.9% Hispanic/Latino, 3.8% Asian, and 2.5% Black/African American). The majority of participants (14% in lab) were recruited and interviewed in schools in the Riverside County.

Materials

In the STEM Task, children were asked to solve a problem that required them to get a ball elevated on a table into a bowl on the floor using a variety of tools (i.e., golf club, lacrosse stick, ramp, paper construction ramp, and a large spoon). The task is presented twice to measure any differences in STEM interest and self-efficacy in the pre-post difference score. Children played 2 STEM games on an iPad. The first game was *Quack's Apples,* in which children roll an apple into pond using incline planes. The second game was *Memory Lane* in which participants recall and select items shown on and disappearing from the screen.

Measures

The participants were interviewed for 15 to 20 minutes. The interview contained 9 measures: STEM Exposure, STEM Interest (Pretest and Posttest), STEM Task (Pretest and Posttest), STEM Self-Efficacy (Pretest and Posttest), iPad Game Understanding and iPad Game Enjoyment.

STEM Exposure. STEM Exposure was measured by asking children 3 questions about their prior exposure to STEM (e.g., What is your most favorite toy?; What is your most favorite show?; What is your most favorite game to play on an iPad?). Responses were coded for if the activity (a) engaged the child in problem solving situations, (b) challenged the child to remembering a sequence or series, (c) involved math or engineering, (d) engaged children in using technology in a complex, cognitive manner, (e) taught science concepts, (f) encouraged the child to actively create or think about art or design, or (g) promoted logical thinking. Activities received a score of 1 for each STEM element included in the favorite activity. An activity was characterized as a STEM activity if it received a score of at least 4. Participants were coded as having STEM Exposure if they had 2 or more favorite activities characterized as STEM activities.

STEM Interest. To assess children's STEM Interest, children were asked 8 questions about their interest in learning about various STEM topics: (a) animals, (b) how a computer works, (c) how to stay healthy, (d) how to build a bike, (e) how to add numbers, (f) how a phone works, (g) building with blocks, and (h) counting. Children could respond to each question by pointing to a picture of a face with a Frown (-1), Neutral (0), or Smile (+1). Ratings for the 8 activities were added to determine the participant's total score, which could range from -8 to 8. Each participant had two STEM Interest scores: before game play and after game play.

STEM Task. Children attempt to solve a task of getting a ball elevated on a table into a bowl using a spoon, racetrack ramp, lacrosse stick, paper ramp, or golf club. To solve the task, children are given one attempt in the first trial. After exposure to the iPad game, children are given three attempts in the second trial. Participants either succeed (1) by using the racetrack ramp, or fail by using any other tools (0).

STEM Self-Efficacy. After attempting to solve the STEM Task problem, children were asked to indicate (a) "How good were you at getting the ball into the bowl?" and (b) "How much did you like getting the ball into the bowl?" Children were given three response options: *not at all* (0), *a little* (1), or *a lot* (2). Each participant had two STEM Self-Efficacy scores: before game play and after game play.

iPad Game Understanding. Next, participants played the iPad game *Quack's Apples* which served to help participants create an analogy between the iPad game and the STEM task. To measure understanding of the game's concept, children answered "What did you use to get the apples into the pond?"

iPad Game Enjoyment. After playing the iPad games, children were asked "How much did you like helping Quack get the apples into the pond?" They were given three response options: *not at all* (0), *a little* (1), or *a lot* (2).

PROCEDURE

First, children were interviewed about their exposure to STEM. Following the interview, participants completed the STEM Interest Pretest questions, and then were presented with the STEM task of getting a ball into a bowl. At pretest, the children were only allowed one attempt to solve the problem. After this attempt, children answered the STEM Self-Efficacy Pretest questions. Then, children played *Quack's Apples* followed by *Memory Lane. Memory Lane* served as a distraction so that children may be tested for their understanding of how to play and solve *Quack's Apples.*
Participants then played the STEM task again and were given three trials to complete the task correctly. Afterwards, they were reassessed for their self-efficacy towards the STEM task post exposure to more STEM from *Quack's Apples.* Their interest in the 8 STEM questions was measured again for any significant differences after the iPad game play.

RESULTS

Does an increase in liking the STEM game correlate to greater understanding of the iPad game?
Pearson's Bivariate Correlations examined the relation between liking the STEM game and a greater understanding of the iPad game. There was a positive correlation between liking the STEM game and a greater understanding of the iPad game (r = 0.111, p = 0.292), but no significant correlation was found. Children's enjoyment of the game did not affect their understanding of the iPad game.
Pearson's Bivariate Correlations examined the relation between the participants' Self Efficacy Pretest Total vs. iPad Game Understand score average (r = 0.02, p = 0.84) and the difference was taken from the participants' Self Efficacy Posttest Total vs. iPad Game Understanding score average (r = 0.14, p = 0.23). This shows there was a positive correlation between children's self-efficacy and their understanding of the iPad game post game play; however, no significant correlation was found.

Does more previous STEM exposure relate to higher self-efficacy in the STEM task?
Pearson's Bivariate Correlations examined the relation between previous STEM Exposure and Self Efficacy Pretest Total. There was a negative correlation between STEM Exposure and Self Efficacy Pretest Total (r = -0.07, p = 0.52), but no significant correlation was found. Children's previous STEM exposure had no effect on their self-efficacy after attempting and possibly solving the STEM task in the pre-test.

Pearson's Bivariate Correlations examined the relation between STEM Exposure and Self Efficacy Posttest Total. There was a negative correlation between STEM Exposure and Self Efficacy Posttest Total (r = -0.1, p = -0.38) but no significant correlation was found. Children's previous STEM exposure had no effect on their self-efficacy after attempting and possibly solving the STEM task in the post-test.

Does STEM Exposure relate to solving the STEM Task?
Pearson's Bivariate Correlations examined the relation between STEM Exposure and Solving STEM Task. There was a negative correlation between STEM Exposure and Solving STEM task (r = -0.17, p = 0.13) but no significant difference was found. Children's previous STEM exposure

had no effect on their ability to solve the STEM task.

Independent samples *t*-tests were run to observe any differences between children's STEM Exposure, Self Efficacy Pretest, Self Efficacy Posttest, STEM Interest Pretest, and STEM Interest Posttest.

Does more exposure to STEM affect boys' and girls' interest toward certain STEM activities

An Independent Samples *t*-test was conducted to compare STEM Exposure for boys (M = 2.71, SD = 0.60) and girls (M = 2.74, SD = 0.50). The *t*-test did not display a significant difference, $t(77)$ = 0.236, p = 0.814, Cohen's d = 0.054; there were no differences between boys' and girls' STEM exposure.

Another Independent Samples *t*-test compared Self Efficacy Pretest for boys (M = 2.37, SD = 0.73) and girls (M = 2.05, SD = 0.66). The t-test indicated a significant difference $t(77)$ = 1.996, p = 0.05, Cohen's d = 0.460; boys had higher pretest self-efficacy than girls.

A further Independent Samples t-test compared Self Efficacy Posttest for boys (M = 2.42, SD = 0.59) and girls (M=2.19, SD=0.93). There was not a significant difference, $t(77)$ = 1.329, p = 0.49, Cohen's d = 0.295, M = -0.268 for boys and M = -0.790 for girls. Also, an Independent Samples *t*-test indicated there was no significant increase in children's self-efficacy after the playing the STEM task, $t(77)$ = 0.438, p = 0.663, Cohen's d = 1.208 M = 0.049 for boys, and M = 0.1316 for girls.

A third Independent Samples t-test compared STEM Interest Pretest for boys (M = 5.17, SD = 2.74) and girls (M = 5.26, SD = 2.72). The t-test did not show a significant difference, $t(77)$ = 1.50, p = 0.881, Cohen's d = 0.032.

The last Independent Samples *t*-test compared STEM Interest Posttest for boys (M = 4.90, SD = 3.34) and girls (M = 4.47, SD = 3.67). The *t*-test did not indicate a significant difference, $t(77)$ = 0.544, p = 0.59, Cohen's d = 0.123. The *t*-test Pretest Posttest difference score demonstrated there was no significant decrease in boys' and girls' interest in STEM after playing the STEM task, $t(77)$ = 0.942 p = 0.349, Cohen's d = 0.214, M = -0.268 for boys, and M = -0.790 for girls.

A Paired Samples *t*-test examined if there were any differences between children's scores in the Self Efficacy & Interest Pretest vs. Posttest. The results for the Self Efficacy measure were not significantly different at pretest and posttest, $t(77)$ = 0.943, p = 0.348, Cohen's d = 0.108. Children's pretest (M = 2.22, SD = 0.71) and posttest (M = 2.30, SD = 0.77) showed no significant increase in self-efficacy.

A Paired-Samples *t*-test revealed a trend toward a significant difference in children's STEM Interest from pretest to posttest, $t(77)$ = 1.880, p = 0.064, Cohen's d = 0.167. Children's STEM Interest decreased slightly from pretest (M = 5.22, SD = 2.71) to posttest (M = 4.70, SD = 3.48).

DISCUSSION

This research attempted to understand the differences in children's self-efficacy and interest in STEM through their previous exposure and an increase in exposure using iPad games. The hypothesis was that an increase in liking the STEM game would correlate to greater understanding of the iPad game; more previous STEM exposure would relate to higher self-efficacy in the STEM task; previous STEM exposure would relate to solving the STEM task; and more previous exposure to STEM would correlate with children's interest toward certain STEM activities or children's self-efficacy toward a STEM task.

Most participants were unable to solve the task in the STEM Task Pretest and Posttest, but more were able to solve the STEM task during the Posttest than the Pretest. This supports that the task was too advanced for children. Some participants even found *Quack's Apples* to be difficult, which could potentially inhibit them from making analogical connections between the iPad game and the STEM task.

There was no significant correlation between STEM Exposure and Self Efficacy Pretest Total (r = -0.07, p = 0.52). And this negative trend continued in the Self Efficacy Posttest Total (r = -0.1, p = -0.38). Previous research has shown that with more exposure to STEM content, children will be able to have a higher understanding (Richert et al., 2011), but in the current research, this neither translates to a higher self-efficacy nor generates positive feelings towards STEM. This is consistent with Meluso et al., 2012, which found that children's exposure to STEM would significantly influence their feelings toward STEM. Because most participants could not solve the STEM task, this could suggest an inhibition of learning new STEM content and therefore a lack of genuine exposure for children.

There was a negative correlation between STEM Exposure and Solving STEM task ($r = -0.17$, $p = 0.13$). Participants with greater previous exposure were more likely to solve the task than those who had less exposure. Again, because the STEM task was difficult, children may not have been able to demonstrate that they can understand and apply the analogical concept from *Quack's Apples* to the STEM task. Thus, previous exposure to STEM would not be sufficient for children's performance in solving the STEM task.

Like Miller et al. (2011), the experimental design did not foster significant increase in children's interest in STEM. However, many did enjoy the STEM game, which supports Gros (2007), in which the interactivity of games may foster children's interest and feelings in STEM. It is possible that because children do not solve the STEM task, they may not feel confident in their abilities or that they are currently performing well. This could potentially lead to a negative mood and an immediate decrease in their STEM interests. This does not suggest that children overall will have a permanent decrease in STEM. Giving children positive reinforcement may be an important factor to consider when teaching children STEM concepts. In the future, expanding the population surveyed and tailoring the STEM task and STEM iPad game towards the children's appropriate age level may yield improvement in STEM interest and feelings. Changing the study to be longitudinal could allow future research to have a deeper understanding of children's self-efficacy and interests.

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