GoldieBlox™ in the 2nd and 3rd Grade: Final Report

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Introduction

According to the US Bureau of Labor and Statistics (2013), only 14.1 of the architects and engineers in the United States were women. Looking further at this statisic, while 25% of architects in the US in 2013 were women, only 7.2% of Mechanical Engineers were women (http://www.bls.gov/cps/cpsaat11.pdf). One proposed method of combating this gender gap is to expose girls to the kinds of toys that develop an interest in building that are typically marketed towards boys. One such toy, GoldieBlox™, was created by a female engineer who was keenly aware of the dearth of females in engineering. The GoldieBlox™ website claims that "By tapping into girls' strong verbal skills, our story and construction set bolsters confidence in spatial skills while giving young inventors the tools they need to build and create amazing things" (http://www.GoldieBlox.com/pages/about). In other words, GoldieBlox™ is not just a pink set of construction tools, it is a toy designed based on research that states girls are more engaged when their verbal skills are employed. This paper outlines the procedures and results of a one year evaluation of the efficacy of GoldieBlox™ to achieve those stated goals within 2nd and 3rd grade classrooms at one girls' school outside of Philadelphia. In order to examine the effectiveness of this construction toy, we ask the questions:

- Is there a relationship between access to GoldieBlox™ and an increased inclination to build, fix or experiment?
- Are the changes in desire to build, fix or experiment greater for second or third grade?

We conclude our report with recommendations regarding the use of GoldieBlox™ in the classroom and discuss areas of future research.

Background Information

Literature Review

Statistical evidence documents that there is a clear gap between the number of men and women who are employed in engineering fields in the United States, yet the exact cause of the engineering gender gap is not known (US Bureau of Labor and Statistics, 2013). Researchers have long posited that discrimination in interviewing and hiring, allocation of resources, choice (either constrained or free) and stereotype threat all may play a role in the limited number of female engineers in the U.S. today (Ambady et al, 2004; Sadler et al, 2012; Ceci & Williams, 2011; Halpern et al, 2007). While discrimination in interviewing and hiring may have been an initial factor in the gender gap, research indicates that such discrimination is no longer apparent (Ceci & Williams, 2011). More importantly, the gender gap is already present when students enter college and select a major, therefore hiring practices cannot be the sole or main cause of the gender gap in engineering. According to the National Science Foundation (2013), in 2010 women completed 50.3% of all Bachelor's degrees in STEM fields, 45.5% Masters' degrees in STEM fields and 40.9% of Doctorates in STEM fields. However, only 1.4% of female college graduates in 2010 completed a bachelor's degree in Engineering as compared with 8.5% of male college graduates. Put another way, only 18.4% of 2010 bachelor's degrees in Engineering were awarded to women (NSF, 2013). This disparity was similar, yet slightly smaller, for Master's degrees and Doctoral degrees. According to these statistics, there is clearly some cause for the lack of female engineers that begins before college matriculation.

One potential reason for the gender gap in engineering fields is that women arrive at college without the prerequisite Math and Science courses and are therefore underprepared for Engineering

majors. In 2005, according to the Nation's Report Card, female high school students completed more credits in Math and Science than males did and had higher overall GPAs in Math and Science (Shettle et al, 2007). However, at the same time males had slightly higher scores on the National Assessment of Educational Progress (NAEP) for Math and Science and male students were more likely to have completed Physics and Calculus whereas girls were more likely to have completed Chemistry and Biology (Halpern et al, 2007). The aforementioned differences, notably, were small (about 1 or 3 percentage points). By 2009 males continued to achieve higher NAEP scores and they began to close gaps in GPA and course taking (Nord et al, 2011). Furthermore, while females were more likely to complete a challenging curriculum, females who did not complete a challenging curriculum were more likely to be missing Math and Science courses than males who did not complete a challenging curriculum (Nord et al, 2011). While there are some gender gaps in high school course taking, the results of the Nation's Report Card do indicate that women arrive at college with at least a similar set of prerequisite courses in preparation for engineering fields.

The finding that women are much less likely to pursue engineering degrees despite arriving at college with similar math and science prerequisites as men indicates that there is likely a degree of choice (albeit a complex choice) involved in the engineering gender gap. Recently, researchers have begun exploring various factors over the course of the lifetime that could influence that choice. In a substantial review of literature Ceci and Williams (2011) suggest that the three most likely reasons for the lack of women pursuing Math intensive STEM degrees (like Engineering) include: fertility/lifestyle choices, preference for a career involving people and ability differences--specifically spatial abilities that are often linked with fields like engineering (Hill, Corbett & Rose, 2010). Notably, Ganley & Vasilyeva (2011) explain that, while girls do trail boys in spatial reasoning, girls' spatial reasoning abilities do not predict achievement. While spatial abilities do not hinder girls' achievement, it is feasible that they might impact choice-making. There are many factors that can influence girls' choice making surrounding participation in

STEM fields, but Ceci & Williams explain that all of these factors (including spatial abilities) could be influenced by socialization beginning prior to adolescence.

Based on a theory of socialization, the gender gap in engineering is likely attributable to what Sheryl Sandberg refers to as an "ambition gap" (2013, p. 15) that is likely caused by some of the same cultural influences that Sandberg cites in relation to a leadership ambition gap (Hill, Corbett & Rose, 2010). Ambady et al. (2001) and Ambady et al (2003) explain that one cause of this ambition gap in STEM concerns stereotype threat. In other words, female students who believe that they are likely to doubt their own abilities because of a perceived assumption that girls are not as strong in STEM fields due to cultural gender roles (Hill, Corbett & Rose, 2010). Self-doubt in STEM fields can be conceptualized as a low self-efficacy in science, which can have a major impact on performance and persistence. Sadler et al (2012) explain that during high school, interest in STEM careers remains stable for males but declines significantly for females. Cultural gender stereotypes, while sometimes serving as a self-fulfilling prophecy, may also lead to bias in resource allocation and treatment by teachers and parents that may occur well before high school, which, through decreased opportunity to learn, may influence both cognitive development and self-confidence (Shakeshaft, 1995). This report documents an example of an intentional "opportunity to learn" and develop confidence in skills that are crucial to pursuing Engineering fields.

GoldieBlox™

GoldieBlox™ is a book and construction set created by Debbie Sterling that, in its first iteration, uses a story to encourage girls to build a belt drive out of wheels, washers and axles. Girls read a book about the main character, Goldie, building a spinning machine for her dog Nacho. As the girls read, they too build a spinning machine. After the first machine is completed, the thought is that girls will build

additional--more elaborate--spinning machines using the models provided in the book. GoldieBlox™, which is marketed to girls ages six through nine, now has three different sets with three different stories including two recent additions: a "parade float" to develop skills with wheels and axles and a "dunk tank" focused on hinges and levers. GoldieBlox™ has received a great deal of positive media attention. For example the toy was featured on the Today Show on December 9th, 2013, and many bloggers express positive experiences with the toy. Despite the positive response from the popular press there has been no identifiable scholarly research to examine the claims that the creators make regarding an increased confidence in engineering related skills.

The Evaluation Procedure

In order to evaluate the efficacy of the GoldieBlox™ toy in encouraging students to build, fix and experiment, we undertook a year long study with 65 2nd and 3rd graders at an independent school for girls outside of Philadelphia, PA. All students were given an "interest in engineering survey" at the beginning of the school year and were subsequently introduced to the toy by way of a hands on demonstration of the GoldieBlox™ by the evaluator. Two sets of GoldieBlox™ were then placed in a prominent location in each classroom for the girls to use during free time. Teachers monitored student usage anecdotally and via a sign-in sheet. At the end of the year, students were given a follow-up survey consisting of the same questions on the initial survey and additional questions specifically about their experiences with the toy. For example both surveys asked students whether or not they like to take things apart to see how they work but only the second survey asked whether or not the students would want to have a set of GoldieBlox™ at home. One teacher did engage her class in using the GoldieBlox™ during Math on two occasions, but for the most part GoldieBlox™ sets were left in a prominent location where students could access them during free play.

Findings

2nd and 3rd grade girls already have strong opinions about their likes and dislikes

While the following sections will outline changes that were observed during the time period that girls were exposed to GoldieBlox™, it is important to know that 2nd and 3rd grade students in this study exhibited strong preferences on the initial interest in engineering survey. Anecdotally, when reading the survey aloud, the evaluator continuously reminded the girls to keep their answers to themselves and they exclaimed (positively and negatively) about their responses to a given question. For example, when reading the question, "I am curious about how electronics work" the researcher noted one second grader screw up her face and exclaim: "That is not like me!" while another practically jumped out of her chair to mark the "A lot like me" bubble. Notably, data do not indicate that students participated in 'groupthink' related to the survey. Data do, however, indicate that each student tended to answer many of the engineering questions in a similar way (see Table 1), which indicates an already strong preference for or against engineering. For example, students who "wonder about how things work" also tend to like to take things part, to persist to "make something work," to like puzzles, to fix things when they break, to draw a picture before building, to make a list of steps, to enjoy doing science experiments and to be curious about electronics. The positive nature of the correlation indicates that girls who do not "wonder about how things work" also tend not to like to take things apart to see how the pieces fit together. Other than that the majority of girls indicated liking to play with Legos or Lego Friends, each girl exhibited consistent preferences either for or against the engineering indicators which documents that before 2nd grade girls may have already begun to make up their mind about what their strengths are.

Table 1: Correlations Among Interest in Engineering Variables

	1	2	3	4	5	6	7	8	9	10	11
1: I wonder about how things work	--	.47***	.40**	-.01	.41**	.44**	.27*	.30*	-.22	.29*.	.55**
2: I like to take things apart and see how the pieces fit		--	.40**	.06	.33*	.49**	.29*	.19	.12	.10	.43**
3: When I build something I keep trying until it works			--	-.00	.30*	.40*	.22	.12	.19	.07	.24

4: I like to play with Legos or Lego Friends				--	.13	.14	.10	.05	.04	.14	.07
5: I like to do puzzles					--	.33**	.135	.162	-.16	.37**	.27*
6: When things break, I try to fix them						--	.30*	.42**	-.07	.21	.42**
7: When I build something, I draw a picture first							--	.37**	-.26	.11	.15
8: When I build something, I make a list of steps before								--	-.29*	.20	.35**
9: When I build something I don't tend to make a plan									--	-.13	-.19
10: I like to do science experiments in school										--	.31*
11: I am curious about how electronics work											--

notes: ** indicates correlation is significant at the $p < .05$ level, ** indicates correlation is significant at the $p < .01$ level

2: There were small but significant changes over the course of the year on several engineering measures

Based on the results of a paired samples T-Test, four measures demonstrated a significant change over the course of the year, documenting limited but significant positive changes during the time period that girls were exposed to GoldieBlox™:

- I like to take things apart and see how the pieces fit together (Increase, $p < .10$)
- When things break I like to fix them (Increase, $p < .05$)
    - Third graders were significantly more likely to display an increase in this question
- When I build something I like to make a list of steps that I should take (Increase, $p < .01$)
- When I build something, I don't really make a plan (Decrease, $p < .05$)

While there were small changes over the course of the year, it is difficult to attribute those changes specifically to GoldieBlox™, especially because there were few significant differences in the rates of change based on student self-reported level of play (with exception of "When something breaks I try to fix it," which had a small but significant positive relationship with level of play).

In order to identify whether or not these changes were related playing to GoldieBlox™, teachers were also asked to reflect on the possible connection. While two 2nd grade teachers reported that it was not necessarily more effective at encouraging engineering skills than the other building toys that were available, one 3rd grade teacher wrote, "GoldieBlox™ was successful in encouraging my students to tinker and think like engineers. This was largely because of the variety of pieces available, the creativity they inspired, and the freedom to create new story lines". Similarly, a 2nd grade teacher wrote, "I do think GoldieBlox™ assists with thinking outside the box and working together to form new creations and ideas. I like that the girls have to use their imagination, yet are able to physically utilize the end product." One third grade teacher gave a mixed review of the toy's ability to develop engineering skills, stating, "Yes, but with limitations. There are only so many things that can be done with the set." Teachers were, therefore, divided on whether or not GoldieBlox truly influenced girls inclination towards engineering.

Teachers were mixed on their response to questions about whether or not GoldieBlox™ encourages engineering skills because many of them felt that GoldieBlox™ were not often utilized, especially at the 2nd grade level. Teachers in both 2nd and 3rd grade reported that "a few students played with the toy occasionally" or that "most students played with the toy a few times". No teacher reported that students played with the toy frequently. Therefore, the teachers responses to the question about the efficacy of GoldieBlox™ were mostly theoretical as the students' play with the toy was limited. One 3rd grade teacher wrote, "Interest in the blocks was high at first. After a few months it tapered off. I think once they felt they had exhausted the possibilities there wasn't as much interest."

3: 3rd graders were more likely to play with the toy than 2nd graders

While the 3rd grade teachers indicated a more causal connection between their observations and the toy itself, this distinction may be because of the differential usage between 2nd and 3rd graders. While 51% of all students surveyed listed that they played with GoldieBlox™ either "Some of the Time" or "A Lot of the Time," 88% of 3rd Graders fell into this category and only 19% of 2nd Graders fell into this category. Furthermore, while 23% of all students stated that they would be very happy to have GoldieBlox™ at home 54% of 3rd Graders fell into this category and only 6% of 2nd graders fell into this category. This distinction is likely the result of developmental differences. When asked what they would change, 2nd graders wrote about making the toy less complex:

"I would change…"

- how complicated it is
- make the string thinner
- that all the animals fall off when you pull the string
- there are too many steps
- when I pull the string it hurts my hand
- sometimes they don't work

3rd graders, on the other hand, wrote about making the kit more complex and more involved, remarking the following:

"I would change…"

- I would put more different pieces in GoldieBlox™
- have more people/animals
- More characters and have a toy Goldie Blox herself
- I would put more pieces
- I think that there should be two strings
- I would put more yellow wheels and purple sticks
- add more pieces, bigger peg board
- add more pieces, make the book more interesting
- more tools
- more girl characters

These remarks from the follow-up survey demonstrate that it is likely that the difference between the 2nd and 3rd graders is be developmental. By the end of the year, third graders seemed to need more complexity, so it may be ideally suited for the beginning of the 3rd grade year.

4: Girls do have access to engineering toys

While not the intended purpose of this review, the evaluator did discover that, contrary to the stated purpose of GoldieBlox™, these girls already had access to engineering toys. In the beginning of the school year 50.8 percent of students noted that they like to play with either Legos or Lego Friends "a lot" and another 23.8 percent of students "kind of" like to play with Legos and Lego Friends. Only one other variable (I like to do science experiments in school) had a higher frequency of students strongly agreeing. Not only do students play with Legos and Lego Friends outside of school, but they also take science classes where they conduct experiments. Further supporting this point, in response to the above question about the efficacy of the toy, 2nd teachers wrote

- "I'm not sure that GoldieBlox™ added to the tinkering that the class previously engaged in during free time. They enjoyed building and being creative with many parts and pieces that can support their imagination. Blocks and Legos were always a popular part of play in the classroom."
- "[GoldieBlox are p]art of several free time toys I have that encourage building. They enjoyed it for a while, but it is not as open ended as a box of blocks."

Both of these comments indicate that the teachers already exposed girls to the toys that build engineering skills. To these two teachers, GoldieBlox™ was no more effective in encouraging building than toys that the girls already had access to. By 2nd grade, the students at this school are clearly already provided access to engineering tools. This definitely does not mean that we should not put GoldieBlox™ in the classrooms, but it does imply that the common narrative that girls are not exposed to building toys does not apply to this school. Furthermore, as will be discussed in the recommendations section, girls tended to make up their own stories rather than follow the story of Goldie. This indicates that GoldieBlox™ is an interesting and useful toy, but not necessarily the magic bullet for these students that it claims to be.

Limitations

While this evaluation was thorough, there are several limitations that need to be addressed concerning generalizability, the lack of control group and the limited long term results.

First, this evaluation is specific to the school in question, therefore it cannot be generalized to other schools or other environments. The school where this study took place is a school for girls with a very strong interest in empowering girls to be leaders and freethinkers. From this, one might anticipate that GoldieBlox™ might have a different impact in a school that is coeducational or in a school that does not already expose girls to engineering toys. Additionally, in order to truly understand the impact of GoldieBlox™, the evaluation would have needed to represent a randomized control study. Given that we wanted all girls to have an experience with the GoldieBlox™ toy and that we could not freely assign students to teachers (or standardize their teaching practices, for that matter), a randomized control study was not feasible. It is difficult, therefore, to rule out developmental changes and other environmental factors as part of the explanation of the increases in engineering interest. Lastly, the results of this evaluation are not long-term as the evaluation only took place over one year. To know if this toy really achieves the aims that it claims to, one would need to undertake a longitudinal study to find out if these girls are more likely to become engineers in adulthood.

Recommendations for the Future

One of the main findings of this study was that the third graders showed a much stronger preference for the GoldieBlox™. There are two possible recommendations that stem from this finding. First, all GoldieBlox™ sets could be moved to the 3rd grade classrooms and combined to allow for more elaborate creative play. Secondly, we could encourage second grade teachers to design more structured play for their students to encourage usage. It is clear that each classroom utilized GoldieBlox™ in a slightly different way. While there were no significant differences in the rates of change for students in the

3rd grade class in which the teacher used the toy in instruction, she did note that she only did this a few times. One could reason that more structured usage may provide different results because it would encourage all students (not those who are already interested) to play with the toy and develop skills and confidence.

A second notable anecdotal finding was that, according to teachers and the girls themselves, the girls tended to make their own storylines, renaming the characters and carrying out the story over weeks. One class, for example, decided that the "sloth" character was the "butler" while another class made him the "janitor." One class described an elaborate stage that they created where they put on "performances" with the characters. While not a recommendation, this finding could provide direction for teachers wanting to engage the girls in more structured play. GoldieBlox™ could be utilized in conjunction with language arts, for example, to have girls learn to write stories. The girls note, further, that they were disappointed that there were not more "girl" characters. Except for a pink dolphin (Katinka), all of the characters in GoldieBlox™ are clearly Male. While they did not indicate that this altered their usage, they did note that they wished there were more girls.

The last finding that provides evidence for future direction is that girls know very little about engineers and other STEM careers. For example, in the first round of surveys 0% of students wrote that they knew "nothing" about being a Math teacher and only 3% of students wrote that they knew "nothing" about being a Science teacher, a full 37% of students wrote that they knew "nothing" about being an Engineer and 67% of girls indicated that they know "nothing" about being a Physicist. After the jobs were described, only 14% of girls described Engineering as "very interesting," and only 13% of students described being a Math teacher as "very interesting" (as compared with a full 44% of students who described being a Science teacher as "very interesting"). This finding indicates that one thing that should be a priority is educating girls about STEM Careers (and making them sound fun) at a very early age.

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