A comparative study on gender bias in the purchase of STEM toys (Fundamental)

Mrs. Huma Shoaib, Purdue University

Huma Shoaib is a graduate student working jointly between Engineering Education and Weldon School of Biomedical Engineering at Purdue University. Her research focus is computational thinking, and understanding computational and engineering identity development in undergraduate students to overcome issues related to women persistence in undergraduate engineering programs.

Dr. Monica E Cardella, Purdue University-Main Campus, West Lafayette (College of Engineering)

Monica E. Cardella is a Professor of Engineering Education at Purdue University.

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Abstract

Children have opportunities to learn about engineering in a variety of settings: in classrooms, through afterschool or summer programming, or through exhibits at science museums. Children can also learn about engineering through interactions with family members or family friends who work as engineers, through television shows, or through books, toys, and games. In an earlier study, we investigated toy-buying patterns and found that adults purchase engineering-related toys more frequently for boys than for girls. We believe that this disparity may be one factor contributing to the underrepresentation of women in engineering as the engineering-related toys can promote interest in engineering and the development of engineering knowledge and skills. In this study, we replicate the previous approach to investigate whether there have been changes in toy-buying patterns over the past four years since the original study was conducted. We follow a similar approach as in the original study: we code online reviews for information about who the toy was purchased for (i.e. a boy, girl, or unknown) and who was purchasing the toy (parent, grandparent, other relative, other, or unknown). Our findings show that the STEM toy purchase for girl child has declined as compared to our previous study. However, recently k-12 teachers have emerged as STEM toy buyers. When teachers purchase STEM toys, this can provide opportunities for both male and female children to be introduced to STEM toys as early engineering resources in classrooms. Additionally, we observed engineering toys targeting girls (e.g. GoldieBlox, Roominate) are a game changer when it comes to the purchase of STEM toys for girls.

Introduction

Motivation

The topic of underrepresentation of women, whether it is in the engineering workforce or academic college or university settings, has been the focus of an overwhelming amount of research. The causes behind this underrepresentation are mainly considered to be resultant of unfair bias in employment as well financial offers made to women in institutional technical positions [5]. Institutional factors play a role in the problem of underrepresentation of women although, [6] indicate that the main cause is not institutional factors but resource availability to women. One of the resources they report is the development of science and math skills in adolescence, commonly this skill gets generated through the use of artifacts (toys) which focus on the child's analytical abilities. Despite the fact that STEM-related toys are available to girl as well as boy children, our previous study [12] reported that there is a gender disparity in the purchase of such toys. Parents, grandparents, and other adults overwhelmingly purchased these sciences, engineering, and math-based toys for male children, suggesting that one of the primary resources for women to balance the engineering work is being heavily underused.

Literature Review (Related Work)

A study on the marketing of toys based on gender segregation was conducted by [1] where they reported that the popular Disney store website does there marketing based on gender segregation. This research gave some generic conclusions: there were a limited number of toys on the website which were unisex, however the marketing was done to attract girl child to buy those toys too which were unisex. The study provides a good reference point on how certain toys are targeted to market based on child gender, despite having only raw data of pictures collected from the Disney website as their primary data.

There is a conflict between the market tactics of selling toys based on gender or the child's own interest or desire in buying a specific toy. A study by [11] found that the relationship between a parents' influence and child's achievement in math or science is complex. According to them there are so many factors involved in this complex relationship being; parents' gender and child's gender, child's interest in math or science and parents' attitude towards child's achievement. They also suggest that there are many more factors involved than just the ones they reported. This study produced results telling how mothers are biased in purchase of STEM related toys for a boy child as compared of girl child, the study provided insights into how this trend persists among different age levels in children.

When it comes to female-female parent child relationship [3] has reported a strong correlation between gendered neutrality of parents towards a unisex toy. They reported that the parent will consider a toy unisex of they were undecided on its market strategy of selling to a child gender. Another study by [11] reports that how math and science education nurtured by parents in child's early childhood has an effect towards child's performance in these subject areas and the choice of occupation decades later.

Gender bias in children's toys is directly targeted by [8] in their study where they refer the importance of play in early childhood. They cite sources which establish the importance of play without toys as well as with toys. They report [13] on how the game of hide-and-seek which involves no usage of toys is important in developing a child's logical thought process. On the usage of toys in child play they cite the work of [15] on toys playing a crucial role in memory of children when they recall play from early childhood. Research by [14] reports the relationship between toys which are stereotypically associated with boys and a child's spatial development. It is very interesting to note that this study used even split of children based on gender to perform experimentation on two kinds of building activities: design and vocabulary. They reported out that group of boy children outperformed group of girl children in the design building activity. All these reported studies suggest that gender bias in STEM related toys is not unfounded, there has been a skew towards purchase of STEM toys for male child as compared to female child.

For a broader view of the gap in engineering between men and women, wage gap based on gender in technical engineering positions is reported by [5]. They collected income data from National Science Foundation and analyzed that the technical positions in engineering suffer from under representation of women at the same time the average income of women is lower than their male counter parts. This finding is a natural extension of the results obtained from the analysis of gender bias in the engineering experience of children, suggesting that the more technical aspects of boys ' engineering toys also apply to the technical side of the engineering industry.

Despite frequent claims that women are discriminated against in engineering, other research has shown that the gender gap in science and mathematics is a product of the resources available to women in these professions. It is reported by [6] that women are well-represented and given the same resources in academia (hiring, funding and publication of research) as their male counter parts. The study establishes the claim that the skew between gender in engineering is due to inappropriate resource allocation and social stereotype of doubting women's ability to work as effectively as men. They report resources to range from amount of time available for work to development of science and math's skills in early childhood. From this perspective, the use of engineering toys when a child is young could be a key resource for a girl who would later be hired in a technical engineering position. Since this research considers that there is no clear discrimination against women, the development of these resources (just to be on par with men) is necessary in order to eliminate any discrimination in workplaces associated with engineering. Research by [10] looked at the purchase pattern of STEM toys towards child gender where the sole purpose of research was to ensure that girls received one resource (engineering and math toys) in early childhood for them to succeed as future engineers, they investigated gender differences in access to STEM related toys by looking into the online purchase pattern of child's family members and other purchasers. They reported a bias in the purchase pattern towards the male child.

The packaging of STEM-related toys can influence a child's learning and the child's strategy towards utilizing the toy as reported by [7]. When Coyle and Liben [7] studied the child's gender and its relationship with child's learning while playing with the toy, it was found that girls learned the mechanical belt-drive principle better from playing with *BobbyBlox (a toy marketed for boys) whereas,* boys learned the principle better from playing with *GoldieBlox (a toy marketed for girls)*. This raises the point that girls can learn engineering concepts from toys marketed specifically for boys and vice versa.

Research Framework

Theoretical Framework

The foundations of this research are based on the concept that children learn through play, toys provide a medium to convey concepts of engineering and science to a child's mind [8]. The developmental or Cognitive view theory mentioned by [9] reports that toys foster reasoning, problem solving and other cognitive functioning in children. Furthermore, the theory sees toy play as helping the child to reach forward towards

mental or developmental challenges that are not, yet a part of child's daily routine or prior set of knowledge related to a concept. Tangrams are a good example of play with an object or toy for purpose of problem solving, pattern recognition and developing reasoning. Hence, toys are important for a child's ability to develop problem solving approach. Play is considered as an activity through which a child develops cognitive abilities [13] and play helps to create new knowledge for the child in addition to the prior knowledge. For example a child can create a square shape from two triangle shapes by combining them which in turn helps the child learn a new shape. Academic education is the primary doorway to learning reasoning and problem-solving concepts, toys are an aid to this learning through activity which will help children apply these concepts in real world.

Research Questions

Our research is a comparative study to explore the toy-buying pattern of engineering and science-based toys on popular engineering toy websites. We wanted to investigate how the science and math toy purchasing trend may have changed in the previous four years since we first studied STEM toy purchasing patterns: is there an incline or decline towards mathematics and science toy purchases for girl children, and how has the trend in purchaser relationship changed in the four-year time period? We were interested in the comparative research because there has been a witnessed increase of trend towards online shopping and people prefer buying toys online as compared to going to a toyshop. We have additional data from online sources to perform a comparative study of toy purchase trend which will provide robust results as compared to previous study of [10]. Our results will provide insights on how science and math's toys can be introduced as resource for children regardless of gender.

These research questions can be summed up as:

1. How has the purchase trend of STEM related toys changed from 2014 to 2018 with regards to child gender?
2. Are there differences in the patterns of toy purchases for boys vs. girls based on the purchaser's relationship to the recipient child in previous four years?
3. What is the purchase trend related to child gender when a STEM related toy like "GoldieBlox" or "Roominate" is purchased which are specifically designed to target girl children?

Methodology

We followed a data collection and analysis procedure similar to [10] in order to perform a comparative study. The procedure provides a sound view of how adults approach the purchase of science and math toy purchase keeping in view child's gender. We analyzed buyer reviews from two high traffic websites which sell science and math toys in fall of 2018. All reviews were analyzed from MindWare.com and Amazon.com which are major sellers of science and math related toys. The previous study [10] also analyzed toys from

the same websites. Mindware.com is a well-known site for purchase of STEM related toys, whereas Amazon.com is the top inline when it comes to online retail. Both websites provide customer reviews and ratings of the toys being analyzed in our study. We included toys which mentioned any of the following areas of STEM in the toy description on websites (see appendix):

- Physics Concepts
- Mathematics and Science
- Engineering and Construction

We analyzed 2974 reviews from Amazon.Com, and 784 reviews from MindWare.com which makes a total of 3785 reviews for 20 STEM related toys. Five toys were related to Physics Concepts, Six to Mathematics and Science, and Nine toys to Engineering and Construction Category. We excluded some toys which were present in [10] study from analysis based on their discontinuity on the seller website. We also excluded those toys from previous data of 2014 because there was no present comparison customer review data available for these discontinued toys. We did not add any new toys that were not investigated in the 2014 study. In each of 3785 reviews we coded the review for:

- Gender of Child the toy is purchased for (Girl, Boy, Unknown)
- Purchaser relationship with child (Grandparent, Parent, Aunt/Uncle, Other)
- Category of toy (Physics, Mathematics/Science, Engineering/Construction)

Reviews had the same informal structure across both websites. Mindware.com provides additional information for their customer reviews where the customer has to specify purchaser relationship as “Reviewing as” where the reviewer can be a grandparent, parent, Aunt/uncle or the child itself. However, Amazon.com does not have this formal structure which specifies the purchaser category while reviewing. The customer may or may not specify category of reviewer in terms of relationship to the child the toy is being bought for. Amazon.com has a general customer reviews system because of the enormous variety of articles they sell online. We only code the purchaser relationship if it is mentioned in the comment. Table 1 demonstrates the review coding process regarding purchaser relationship at Amazon.com.

Toy Name	Customer Review	Purchaser Relationship Identified (✗/✓)	Relationship category
Chaos Tower	*“Concept is great; parts do not fit together all that well. Some of the tower parts fit together so loosely that they tend to fall apart, and*	✗	NA

	some of the parts that are intended to attach to ball joints don't. A little more QC in manufacture would go a long way."		
Chaos Tower	*"This is the worst product. I bought it for my classroom and used it briefly. Pulled it out to try again this year and it is just worthless. The company never responded to my request for a refund."*	✓	Other (teacher)
Chaos Tower	*"Our granddaughter is almost 11 and she built the tower in about 7 hours. It is running like a champ! We have a nice video showing the trial runs. We will definitely be looking for other challenging kits to stir her inner engineering genius."*	✓	Grandparent

Table 1: Coding process of purchaser relationship with child the toy is being bought for.

In order to keep consistency in coding process the categories of purchaser relationship defined for reviewers in Mindware.com were adapted. The customer reviews for Amazon.com were also coded in the same categories. We faced coding issues while analyzing comments, relationships of older generation which were not grandparents, but great-grandparents or great-grand aunts were considered equivalent to grandparents and included in the grandparent category pf purchaser relationship to child. Secondly, purchasers who bought a toy for both a boy and a girl presented a problem forcing both sexes to be coded for the same review. These reviews were not coded for child gender because it could have skewed the data.

Results

Slight differences in quality of reviews were noticed across and even within a website. More than half of the customer reviews had no information regarding the gender of the child the toy was being purchased for as illustrated in Figure 1. In 2018 almost 55% of the reviews provide no information about the gender of child the toy is being purchased for, this shows more than half of the data is useless when it comes to research regarding child gender in purchase of stem toys.

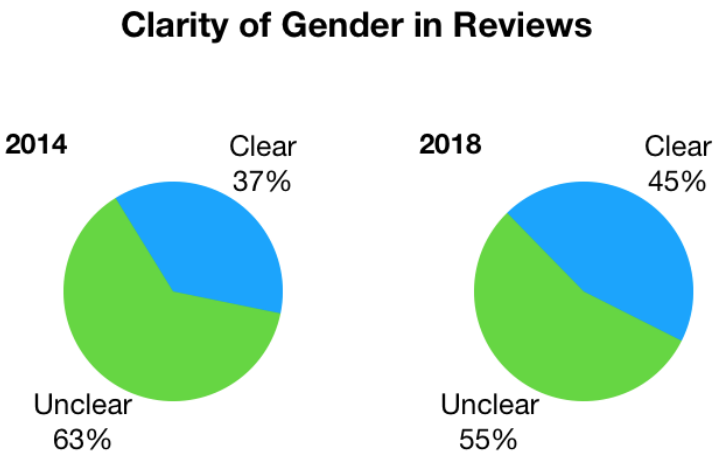

Figure 1: "Clear" indicates the reviews included gender specific information about the child the toy was being bought for. There has been a 7% increase of information regarding clarity of child gender in the overall customer reviews in previous four years.

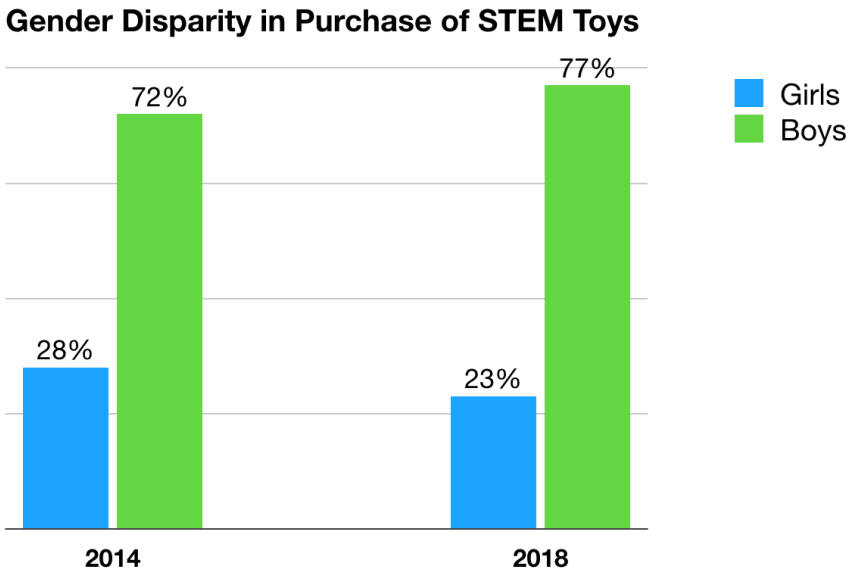

Figure 2: Representation of the child gender the toy was bought for. The results indicate a decline of 5% in purchase STEM related toys for the girl child in 2018 as compared to 2014.

When it comes to gender bias in purchase of STEM related toys, 77% of toys were bought for male children based on the analysis of the 45% of reviews in which child gender was specifically mentioned across both websites, Amazon.com and Mindware.com in customer reviews. In 2018, 91% of toy purchasers were family members, which shows a strong indication of family members preference towards buying STEM related toys for boy children over girls.

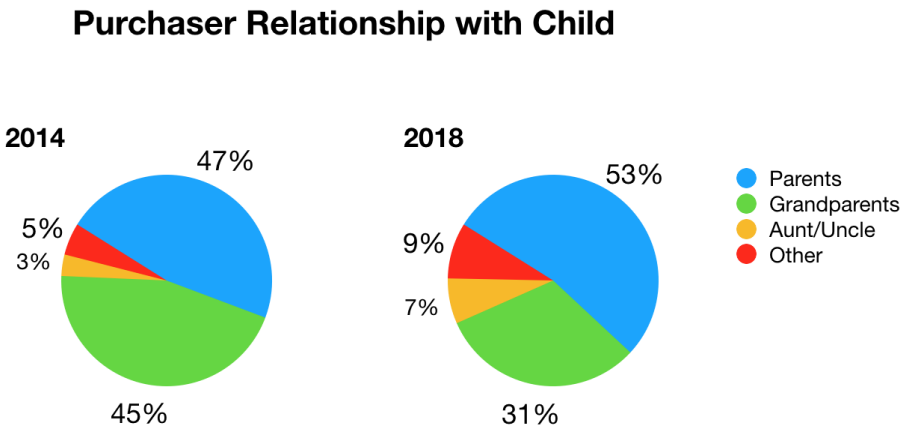

Figure 3: Relationship of purchaser to child in reviews where the child gender was specific. The category "Other" indicates purchasers who identified themselves other than that of the specified categories mentioned above.

The top two purchasers of STEM-related toys are parents and grandparents. At the same time, statistical results indicate that these STEM-related toys are preferred being bought for boy children as compared to girl children. The relationship between purchaser relationship to child and purchase trend towards boy child sufficiently explains generational bias in the STEM toy purchase. Thus, although gender equality has been prevalent in the media in recent times, these trends do not appear to have extended to include gender neutral toys or the purchase habits among family

members. However, STEM toys targeting girl children have emerged recently to generate interest towards engineering amongst girls.

“GoldieBlox” and “Roominate”

Recently, STEM-related toys targeting girl child have emerged in the market and are being sold on Amazon.com (and other retailers). We analyzed and coded reviews of two toys namely “GoldieBlox” and “Roominate” and checked for gender bias in purchase of these toys. 178 customer reviews were analyzed from Amazon.com. Purchaser relationships were identified for these toys. However, the customer reviews show that these toys were only bought for girl children; there was not a single review where one of the toys was bought for a boy child. While analyzing customer reviews, we came across the following review:

“My granddaughter told me this was her favorite present this year. My son-in-law is a racing engine builder by profession and the two of them love to work on these kits together.”

This unique customer review provides insight on: the child’s own will regarding purchase of the toy and the influence of parent's profession and interest towards the engineering toy.

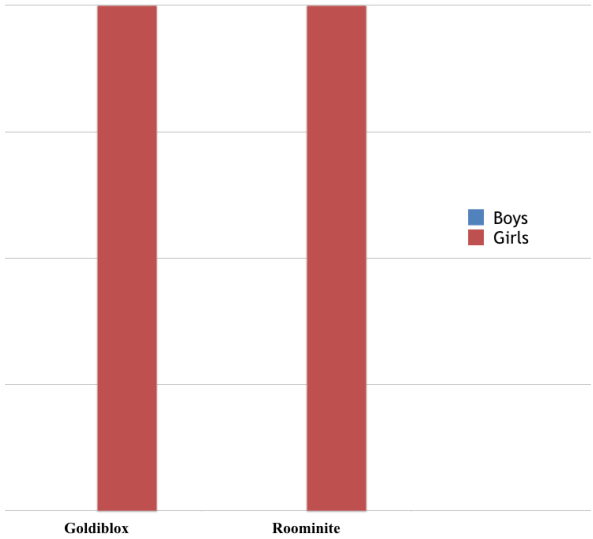

Figure 4: Representation of the child gender ‘STEM related toys targeting girl children’ was bought for. The customer reviews show the purchasers only bought these toys for the girl child.

Discussion

There has been a 5% decline in purchase of STEM related toys for girl children in the past four years when comparing the purchasing trends of the twenty toys analyzed in the previous study [10] compared to the purchasing trends since that study was conducted. However, the emergence of STEM-related toys targeting girls may have turned the tables and our analysis show these toys are only been bought for girls. Also, we observed as the number of customer reviews analyzed increased in last four years, the 5% decline is showing a more realistic measure of gender bias in purchase of STEM related toys. Marketing tactics and traditional influences in old generation are culprits giving rise to this gender disparity when it comes to purchase of STEM related toys. The fact that 'parents are major in line purchaser of these toys' and 'gender bias has only increased in this purchase pattern' is an indicator of how traditional thinking from old generation along with marketing tactics has influenced thoughts of young children's parents

On the positive side, K-12 teachers have emerged as STEM-related toy purchasers since 2014. Teachers introducing STEM-related toys in school classes and summer camps can help bridge the gap of resource availability of STEM related toys in early childhood for female children. Our methodology could not quantitatively account for the dynamics of the purchase of one STEM toy by a teacher for tens or hundreds of children. However, it shows a promising future for girl children who would be introduced to these toys in school classrooms. Teachers emerging as STEM toy buyers also show a trend towards play pedagogy in k-12 classrooms where children learn through play with STEM related toys.

Limitations

Just over half of the customer reviews (almost 55%) had no information about the gender of the child the toy was being purchased for. The lack of clarity regarding child gender in 55% reviews cannot be ignored. The 55% customer reviews which have no clarity on the gender of child the toy is being bought for can absolutely reciprocate our results.

Future Research

While analyzing the reviewer comments on Amazon.com and Minware.com, the degree of involvement by the reviewer while the child was playing with a construction-based toy was reported. However, child gender information in these comments was not clear. Hence, it was difficult to access if the children who needed adult involvement while playing belonged to a specific gender. We believe, these comments could help with child development studies to see which specific toys needed involvement by an adult while the child is playing and would help to re-evaluate the age group of children the toy is suitable for.

With the available reviewer comments data, researchers could analyze reviewer comments for a multitude of findings regarding; age appropriateness of toy, quality of the toy, if the child demanded to acquire the toy, teacher involvement in the purchase of STEM toys. While the scope of this research did not provide time to perform a detailed qualitative analysis of the reviewer comments, the abundance of reviewer comments data on STEM toys provided on both websites has the potential to, provide a jumping off point

to research in areas of marketing and child development studies regarding child gender in STEM toys.

Acknowledgements

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Appendices

Table 1: Toys included in the review

Toy Name	Area of Focus	Total Number of Reviews 2012	Total Number of Reviews 2018
Mindware physics Workshop	Physics Concepts	51	71
Mindware Q-BA-MAZE 2.0: Big Box	Engineering and Construction	51	717
Mindware Microscopic kit & book	Math & Science	50	124
Mindware Chaos Tower	Engineering and Construction	43	68
Mindware Equate	Math & Science	51	51
Mindware KEVA Contraptions (200 Plank)	Engineering and Construction	50	70
Mindware Snap Circuits (500 piece)	Physics Concepts	32	174
Mindware KEVA Contraptions (400	Engineering and Construction	11	31

Plank)			
Mindware Q-BA-MAZE 2.0: Mega stunt set	Engineering and Construction	47	74
Mindware Recon Rover with obstacle course	Physics Concepts	24	24
Science Wiz Inventions kit	Physics Concepts	20	20
Thames and Kosmos Chemistry Chem C500	Math & Science	29	29
Young Scientist Series - Magnetism, Static Electricity, Tornadoes	Math & Science	9	9
"Thames and Kosmos Alternative Energy and Environment Science - Wind Power"	Engineering and Construction	18	18
ThinkFun Math Dice Jr.	Math & Science	30	30
"Elenco Snap Circuits Electromagnetism"	Engineering and Construction	20	20
Thames and Kosmos Remote Control Machines	Engineering and Construction	30	30
ThinkFun Math Dice Powers	Math & Science	10	10
K'NEX Education - Intro to Simple Machines: Levers and Pulleys	Engineering and Construction	26	26
4M Magnet Science Kit	Physics Concepts	22	22