

Representations of Underrepresented Characters in Engineering Children Books

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Abstract—Women, people with disabilities, Blacks, Latinas and American Indians are considered underrepresented in engineering fields because they constitute a small portion of engineering students and the population of professional engineers in the United States. In order to increase underrepresented engineering degree recipients, it is necessary to provide opportunities for underrepresented students to develop their self-concept and experience positive and effective pre-college engineering experiences. Children's experiences are potentially influenced by picture books. Previous studies reveal that children compare themselves with the characters in their books who share the same backgrounds and consider the characters as role models (e.g. [1] & [2]). The picture books characters can affect children's perceptions of their backgrounds and influence their self-concepts. To address this possibility our research team examined children's books about engineering. We looked into the portrayal of underrepresented characters in 14 engineering picture books for children ages 4-8. To examine the characters' genders, ages, ethnicities, and abilities, we conducted a quantitative content analysis of these picture books based on Krippendorff's method [3]. The result of the study indicates that, though still being underrepresented, different groups of underrepresented populations are depicted more frequently in engineering picture books than the engineering field itself.

Keywords—*children book; underrepresented populations; engineering.*

I. INTRODUCTION

According to an NSF report [4], women, minorities, and people with disabilities are considered underrepresented in the fields of engineering and science. The report argued that their underrepresentation not only differs in areas of study and occupation, but also depends on their participation and achievement in pre-college and higher education science and engineering-related experiences. On the other hand, the National Academy of Engineering argued that many children have limited knowledge about engineering and engineers; consequently, this perpetuates into adulthood [5]. Moreover, when children have lack of engineering knowledge, their

interests towards engineering may not develop. Therefore, exposing students to engineering and delivering messages about engineering to students at younger ages seems necessary. One way to convey messages to young children is through story books. Thus, in this study, we examined engineering children books and studied how they depicted underrepresented people.

II. LITERATURE REVIEW

A. Role of society

Society plays an important role in directing individuals' behaviors and framing their lives [6]. Traditionally, society has given different social statuses to the various social categories, including race, social class, and gender. Consequently, the members of these social categories use the sociological perspectives [7] and set values, expectations, and responsibilities associated with their social statuses [6]. Defining expectations regarding to an individual's social status is the process of socialization [8]. Socialization may result in individuals depriving themselves (or being deprived) from certain activities that influence their future career paths. The process of socialization not only affects adult's lives but children's lives. Children, even in at young ages, through socializations, process the information around them and set expectations regarding their abilities and their place in the world [8]. Gender stereotypes about engineering is one example that may prevent women from being engineers.

B. Importance of children's literature

One way of communicating knowledge and conveying social messages to children is through literature. Children's literature can potentially influence children's lives [9]. It helps children to not only learn about their own culture and language, but also others cultures and languages. Children's value can be shaped through the power of books [6], and through the power of images and texts, they often come to appreciate the reality of the world and their social place within it [10]. Picture books, as

one form of literature, demonstrate reality to children and help them reflect on it. Moreover, Rajput discussed the importance of books in children's development and growth as both "mirrors and windows" [11: 63]. "Books, especially multicultural books, are like mirrors [that] let readers see reflections of their own lives; windows [that] let them see others' lives" [11].

Including a diverse and multicultural set of characters in children's literature has many advantages [9]. One advantage is portraying diverse role models for children. According to Golos and Moses, many researchers argue for the necessity of providing underrepresented children with role models from the same cultural and linguistic backgrounds [9]. For instance, the same study suggests that deaf children benefit from having role models within the Deaf community. Moreover, Anderson and Hamilton show that children's self-esteem increased when they see characters with the same-sex in a storybook as their role models [1]. Exposing children to positive role models who convey social messages via either images or text is important from young ages. Self-esteem is positively correlated to job satisfaction [12] and self-efficacy influences vocational interests and the range of perceived career options [13]. According to Bowles, children get to know themselves from age three to five [13]. They may easily be biased by inappropriate role models who hold negative stereotypes about their race, ethnicity, gender, and ability. On the other hand, their identity will be influenced by what they read or see about positive role models as well.

Traditionally, children's literature has not included many characters with diverse cultural backgrounds and disabilities. Even in the cases that such characters were included, they often provided negative messages to readers [2]. However, today, children's literature includes more diverse characters, places, and events (Nilsson, 2005). As a result, researchers are also paying attention to the portrayal of characters of different races, ethnicities, and those with disabilities [9]. Moreover, many studies examine the way gender stereotypes and women's roles in society are depicted in children's literature (e.g. [6]).

C. Purpose of Study and Research Questions

The number of children's books related to engineering has increased in recent years. Given the importance of children's literature and its impact on students' identity and their lives, examining the portrayal of these stories' characters is important for engineering education researchers who want to encourage more students to engage with engineering. Moreover, information on how media like children books reflect engineering for children is important for the relevant publishers to diversify the composition of engineering-related literature for children. Thus, the purpose of this study was to analyze the portrayal of characters in children's engineering books targeting the age range of 4-8 years. The research questions of the study are as follows:

1) How frequently are underrepresented characters in engineering-related children books depicted as main characters?

2) How frequently do engineering-related children books depict underrepresented characters?

III. METHODS

This study is designed to investigate the portrayal of underrepresented characters in children engineering picture books. "Content analysis is a research method that uses a set of procedures to make valid inferences from text" (14: 117). According to Krippendorff, text can include but is not limited to words, pictures, images, or any other object which holds and conveys meaning to someone [3]. Quantitative and qualitative content analysis can be used to analysis text; however, quantitative analysis is utilized where the aim of the study is to count and measure categories and variables. Therefore, in this study we utilized quantitative content analysis as the research method.

A. Identifying a Sample

In order to address our research questions, we first compiled a list of 40 engineering books available in the library of a research institute for pre-college engineering for children. All of the books in this library were previously collected and reviewed by a research team for a project called Engineering Gift Guide. The books were confirmed by the Engineering Gift Guide team as texts that promote engineering thinking and design. Our research team then established four selection criteria to narrow down the sample. The four criteria includes the following:

- (1) The book must be a picture book.
- (2) The book must be fiction.
- (3) The book must be appropriate for ages 4-8.
- (4) The book must receive 4 to 5 stars by customers from two major book retailers (Amazon.com or BN.com).

Based on these criteria, we carefully selected 15 books for analysis in this study.

B. Coding

According to Boettger and Palmer, in quantitative content analysis researchers must determine terms or concepts before evaluating texts and draw conclusion based on the inferential statistics of the frequency of the concepts [15]. In this study we utilized three main categories as the themes for evaluating the picture books. These themes—race, gender and disabilities—are significant in defining underrepresented people in engineering [4]. The first theme, gender, included female, male, and neutral. The second theme, race, included three sub-categories: represented, underrepresented, and not applicable. Underrepresented includes Black, Latinas, and Native American. All other races were considered as represented. The third theme, disabilities, included three main sub categories: Fully Able, With Disabilities, and not applicable. Eight types of disabilities were studied as sub-sub-categories of "With Disabilities." We also added an alternative theme of "type of character" to identify if the character is human being, animal, object, or other.

Based on these themes, the first author developed the codebook. The codebook included the definition of each theme and characteristics that could help us while coding. The aim of studying the themes was to count the characters and determine which sub-category was represented most often. In order to code the data that did not fall within these sub-categories, we added “unclear” to all themes.

The coding in this study was done in two phases. In the first phase, we studied the main character of the books and operationalized their type, genders, races, and disabilities. The unit of the analysis for coding in this phase was the character level. During the second phase, we were interested in analyzing the depiction of all characters based on their type, gender, race, and disabilities. The units of analysis for coding in the second phase were book and page level.

C. Validity and Inter-rater Reliability

After both authors agreed on the themes, the first author developed the codebook and performed a dry run of the initial codebook on one book that was not included in the study selection. Based on the dry run, the codebook was improved. According to [15], training raters and the collaboration process elucidate the interpretability of the coding categories and establish and increase its validity. Thus, the first author trained the second author by explaining the codebook and the coding process.

In order to evaluate inter-rater reliability, a sample of 10% of the selection is essential to be assessed during the training phase [15]. Thus, we randomly chose two books from the 15 selected books, and separately coded them. We then compared our codebooks, measured our interrater agreement, and reached the sufficient agreement. The percent agreements between the two raters ranged from 87.7% (with Cohen Kappa : 0.736) to 100% (with Cohen Kappa : 1.0) on each individual theme. We reconciled the disagreement through discussion and finally altered the codebook by adding more information regarding each theme.

D. Data Analysis:

Before coding each book, we read the picture book to get a sense of the story and to make our coding process more accurate. After the coding process was done, we counted the frequency of the individual categories, including the type, race, gender, and disabilities of the main characters from the 14 books. In this calculation, we examined the frequency of each sub-category. For example, we counted the frequency of the main characters who are fully abled or have disabilities. Then the frequency of the each type of disabilities (e.g., Vision, Physical, etc.) was calculated. The same calculations were conducted for all the characters in the 14 books as well as for the pages of the books.

IV. FINDINGS AND DISCUSSIONS

A. Phase 1: Main Characters

In the first phase, we focused on the main characters of each book and we focused on the first research question: How

frequently are underrepresented characters in engineering-related children books depicted as main characters?

Among the 14 books coded, we identified 14 main characters. One character is gender neutral, and 9 characters could not be classified into presented or underrepresented group. When there is no explicit evidence or indication of disability, we assumed the characters to be fully abled.

1) Genders

A first category we examine is the gender distribution. Of the main characters in the books, 7 are female and 6 are male, an almost equal distribution of genders. According to NSF statistics (2015), about 20% of the engineering degrees of all levels were awarded to women in 2012; about 30% of engineering occupations were held by women in 2013. The children’s book provide a more balanced gender representation than the engineering field.

2) Race

Among all 14 main characters, we were able to identify the race of only five of them; three are from underrepresented racial groups, while two are from represented racial groups. Due to the limited data on race presentation, we cannot draw a conclusion about the presentation of race in children’s book main characters. Unlike gender, sometimes race is not explicitly depicted for each character in children’s book. Since only five out of the 14 books specifically indicate race and ethnicity, we could argue that when authors are creating children’s picture books, race and ethnicity is not always a factor they consider in the process of developing a character.

3) Disability

The third category is looking at people with full ability and people with various disabilities. According to the NSF [4], 12% of the U.S. population has some disability. Among the main characters of the 14 books selected, 12 are fully abled and 2 are people with disabilities, which is around the average presentation of people with disabilities in the US.

TABLE I. FREQUENCY OF DIVERSE REPRESENTATIONS IN MAIN CHARACTERS

<i>Gender</i>		<i>Race</i>		<i>Disability</i>	
Male	44.16%	Represent ed	37.84%	Fully Abled	93.30%
Female	38.12%	Underrepr esented	25.77%	With disability	5.84%
Unclear	6.04%	Unclear	12.07%	Unclear	0.86%

B. Phase 2: All Characters

In the second phase we focused on all characters’ portrayals in the books, and we focused on the second research question: How frequently do engineering-related children’s books depict underrepresented characters?

Among the 14 books we coded in this work, there are 1044 characters in a total of 435 pages. Humans and animals constitute 93.87% of the 1044 characters, and 6.13% of the characters were machines or objects.

1) *Genders*

The frequency of male characters depicted is 44.16%; 38.12% of the characters were female. As indicated in Table 2, female characters appear less frequently than male characters. However, the difference in the percentages presented in this sample is 6.04%, which is not as significant as the difference in college enrollment, degrees awarded, and practitioners in the field.

2) *Race*

The second category compares the frequency of underrepresented populations with presented population. Underrepresented populations in engineering appear 25.77%, while the represented populations appear 37.84%. Table 2 shows a difference of 12.07% in the frequency between the underrepresented and presented groups. Even though this result shows a consistency of defining the underrepresented racial group between children’s books and real life, this number is not as large as the racial inequities present in engineering enrollment, degrees awarded, and engineers practicing today.

3) *Disability*

Table 2 indicates that 93.30% of the characters in the books were people with full ability; however, only 5.84% had some disabilities, including vision and mobility impairment. Table 2 displays a significant lack in the presence of people with disabilities in children’s books. The representation of people with disability is lower compared to the general population in the United States.

TABLE II. RACIAL AND ABILITY DIVERSITY AMONG ALL CHARACTERS

<i>Gender</i>		<i>Race</i>		<i>Disability</i>	
Male	6	Represent ed	2	Fully Abled	12
Female	7	Underrepr esented	3	With disability	2
Unclear	1	Unclear	9	Unclear	0

V. CONCLUSIONS AND IMPLICATIONS

Children books are useful tools for sharing positive messages about engineering to underrepresented readers. Moreover, engineering-related books help children to see characters as role models and develop strong perceptions of engineering as a possible future career. Therefore, in this study we examined the portrayal of minorities, women, and people with disabilities in engineering-related children’s books. Our findings demonstrated that the frequency of women and racial minorities represented in children’s books are relatively higher than their participation in the engineering field. However, they still constitute smaller portions of the characters than men and represented populations. This finding suggests that even though children’s literature publishers are paying good

attention to these populations, a long journey is ahead in terms of providing equitable depictions. Meanwhile, a lacking representation of people with disabilities may call for publishers to create more characters with disabilities to help this population engage with engineering. Children’s books present a demographic that is addressing more equal representation of people from diverse backgrounds in world of engineering.

Exposing children, particularly underrepresented children, to more engineering-related children’s books may increase the likelihood of these young people seeing themselves capable of being an engineer and choosing engineering as their career path. In this study, we only focused on the frequency of all the characters. However, further studies could examine the roles that both represented and underrepresented characters play in the stories. In addition, qualitative studies are needed to define the messages that underrepresented characters send to children with the same cultural backgrounds. Furthermore, a very limited number of studies, if any, explored what aspects of engineering these children’s books are representing. Thus, more studies are necessary to examine the engineering knowledge or skills these books would potentially promote in children.

VI. LIMITATION

Since the study uses an existing collection of engineering books from the Engineering Gift Guide project, our study may have encountered two limitations: 1) the quality of the books; and 2) the quantity of the books. The institute in charge of the Engineering Gift Guide has a very good reputation for conducting pre-college engineering-related research. Therefore, we have not measured the quality of how it develops children’s engineering interests. On the other hand, the sample size of our study was sizeable but not significant. Thus, we may have neglected some books that have depicted gender, race, and people with disabilities. The relatively small sample may have led the presentation of main characters to be less significant in statistics. The sample set used in this study was published in English, which leads to a potential skewed representation of races in all books published in the US. Even though we have paid careful attention when coding the books, coding is done by human researchers, so some characters may have been missed in the coding process.

REFERENCES

[1] Anderson, David A., and Mykol Hamilton. "Gender role stereotyping of parents in children’s picture books: The invisible father." *Sex Roles* 52, no. 3-4 (2005): 145-151.

[2] Kama, Amit. "Supercrrips versus the pitiful handicapped: Reception of disabling images by disabled audience members." *Communications* 29, no. 4 (2004): 447-466.

[3] Krippendorff, Klaus. *Content analysis: An introduction to its methodology*. Sage Publication, 2012.

[4] National Science Foundation, National Center for Science and Engineering Statistics. 2015. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2015. Special Report NSF 15-

311. Arlington, VA. Retrieved from <http://www.nsf.gov/statistics/wmpd/>.
- [5] Davis, Lance A., and Robin D. Gibbin, eds. *Raising public awareness of engineering*. National Academies Press, 2002.
 - [6] Taylor, Frank. "Content analysis and gender stereotypes in children's books." *Teaching Sociology* (2003): 300-311.
 - [7] Mills, C. Wright. *The sociological imagination*. Oxford University Press, 2000.
 - [8] Jablin, Fredric M., and Linda L. Putnam, eds. *The new handbook of organizational communication: advances in theory, research, and methods*. Sage Publications, 2001.
 - [9] Golos, Debbie B., and Annie M. Moses. "Representations of deaf characters in children's picture books." *American Annals of the Deaf* 156, no. 3 (2011): 270-282.
 - [10] Crabb, Peter B., and Deb L. Marciano. "Representations of material culture and gender in award-winning children's books: a 20-year follow-up." *Journal of Research in Childhood Education* 25, no. 4 (2011): 390-398.
 - [11] Rajput, Toby. "Questioning your collection." *Knowledge Quest* 38, no. 1 (2009): 62.
 - [12] Judge, Timothy A., and Joyce E. Bono. "Relationship of core self-evaluations traits—self-esteem, generalized self-efficacy, locus of control, and emotional stability—with job satisfaction and job performance: A meta-analysis." *Journal of applied Psychology* 86, no. 1 (2001): 80.
 - [13] Lent, Robert W., Steven D. Brown, and Kevin C. Larkin. "Self-efficacy in the prediction of academic performance and perceived career options." *Journal of counseling psychology* 33, no. 3 (1986): 265.
 - [14] Weber, Robert P. 2004. "Content Analysis." Pp 117-124 in *Social Research Methods: A Reader* edited by Clive Seale. New York, NY: Routledge.
 - [15] Boettger, Ryan K., and Laura A. Palmer. "Quantitative content analysis: Its use in technical communication." *Professional Communication, IEEE Transactions on* 53, no. 4 (2010): 346-357.