The Impact of Robot Projects on Girl's Attitudes Toward Science and Engineering

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Introduction

The gender gap in engineering, science, and technology has been well documented [e.g., 1, 2], and a variety of programs at the k-12 level have been created with the intent of both increasing girl's interest in these areas and their consideration of them for careers [e.g., 3, 4, 5]. With the development of robotics platforms that are both accessible for k-12 students and reasonably affordable, robotics projects have become a focus for these programs [e.g., 6, 7, 8]. While there is evidence that shows robotics projects are engaging educational tools [8, 9], a question that remains open is how effective they are in reducing the gender gap.

Over the past year, an in-depth study of participants in a robotics educational program was conducted to determine if such programs have a positive impact on girls' self-perception of their achievement in science, technology, engineering, and math areas (STEM), and whether this translates into career choices. To examine social and cultural issues, this study applied a long-standing model in motivation theory, Wigfield and Eccles's [10] *expectancy-value theory*, to examine a variety of factors that surround girls' perceptions of their achievement. Expectancy-value theory considers that individuals' choices are directly related to their "belief about how well they will do on an activity and the extent to which they value the activity" [5, p. 68]. The expectancy-value model of achievement performance and choice focuses on individuals' value of the task and their expectations of success to determine achievement-related choices.

Methods

The study involved participants in the KISS Institute for Practical Robotics' Botball Program (www.botball.org). The Program engages thousands of middle and high school students in regional and national robotics competition in a team-based activity that includes a cooperative component and a competitive component [11]. The program starts with a hands-on teacher/student workshop. Equipped with this knowledge and a robot kit, teachers mentor students in the development of the project. The students have 7 weeks to design, build, and program a team of small mobile robots.

Participants were recruited from 7th grade classes who had not previously participated in the Botball program. Twelve all-girl teams and 24 mixed teams comprised the sample. Teams came from 13 states, representing all regions of the country. Using a modified version of the Michigan Study of Adolescent and Adult Life Transitions [12], participants were tested prior to beginning the program (pre), and immediately following the competition (post). To measure the indirect effects that perceptions, goals, and self-schemata have on achievement related choices, structural equation modeling (SEM) was used. SEM is a technique that allows for the modeling of relationships between multiple variables in complex systems where both direct and indirect relationships exist.

The quantitative study was complemented by a qualitative study that followed four teams: two all-girl teams and two mixed-gender teams. The qualitative study helped us to identify and understand "causal connections in the lived experiences of participants" [12, p. 15]. It also allowed us to gain an understanding of girls' unique and personal experiences and what effects participation may have on their future decisions. Data were collected from several sources, including interviews of parents, mentors and students; observation of team sessions; videotapes by both researchers and student participants of team sessions; and documentation and blog entries produced by the team members. Data from the different sources provided a multi-layered understanding of participants' experiences that enabled us to create thick, descriptive narratives of each team. Trustworthiness of research findings was established through triangulation of data. Triangulation involves cross-checking interpretations and data obtained from multiple, independent approaches and sources [13].

Experimental Results

The quantitative data was examined in a two step process. First, we employed SEM to explore the fit of the expectancy-value model with our data. Overall, the expectancy-value model was a good fit. In support of the model, we found that beliefs in traditional gender roles led to negative self-concepts for science and engineering tasks while positive self-concepts then led to positive expectations of success, which in turn led to more positive attitudes towards science and engineering careers.

In step two, we used the results of the model to look for the impact of participation in Botball. Employing a series of Analysis of Variances (ANOVA's), we found that the attitudes of girls towards a career in engineering significantly increased as a result of participation. We also found that girls in the mixed-gender teams experienced an increase in positive attitudes toward long-term goals in science due to the program. Interestingly, we found the converse for girls in all-girl teams who actually experienced a slight decrease in attitudes. Results also revealed that participation in Botball served to reduce beliefs in traditional gender roles.

The multiple data sources used in the qualitative part of this study enabled us to build descriptive narratives of four diverse settings, teams, and participant experiences. The data enabled us to obtain insights into trends observed in the quantitative part of the study. Among themes that emerged from the qualitative data were the influence, role and style of mentors in girls' experiences on teams; effect of strategies for recruiting and selecting team members on perception of abilities in STEM areas; relationship between understanding of career requirements and choice of STEM related courses; and the role of factors, such as team cohesion, on students' perception of the value of experiences such as Botball in future choices.

Conclusions

The results of this study provide evidence that participation in Botball may help to reduce the gender gap in science and engineering through reducing beliefs in traditional gender roles and increasing positive attitudes about engineering and science and careers in these areas. Given that the Botball program lasts only seven weeks, these results indicate the short-term, well-structured programs that can effectively modify social and cultural beliefs may be particularly promising in encouraging girls to pursue STEM areas for study and careers.

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