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The Effect of the FIRST Robotics Program on Its Graduates

Shahaf Rocker Yoel [1], Daphna Shwartz Asher [1], Maayan Schohet [2] and Yehudit Judy Dori [1,3,4,*]

1 The Faculty of Education in Science and Technology, Technion-Israel Institute of Technology, Haifa 3200003, Israel; shahafr@campus.technion.ac.il (S.R.Y.); sdaphna@ed.technion.ac.il (D.S.A.)
2 The Faculty of Electrical Engineering, Technion-Israel Institute of Technology, Haifa 3200003, Israel; Maayan-s@campus.technion.ac.il
3 The Samuel Neaman Institute for National Policy Research, Haifa 3200003, Israel
4 School of Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139, USA
* Correspondence: yjdori@technion.ac.il

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Abstract: The program For Inspiration and Recognition of Science and Technology (FIRST) for young students incorporates project-based learning (PBL) with designing and building wireless-controlled robots. The students are guided by experts, mostly engineers. The FIRST organization determines the theme of the robot annual competition. The goal of this research is to characterize and evaluate the effect of the FIRST program on graduates' self-efficacy, interpersonal skills, and career choices in science, technology, engineering, and mathematics (STEM). The research participants included 297 FIRST graduates, mostly high schoolers, who responded to questionnaires, and five of them were interviewed. Analysis of the data showed that the FIRST program improved graduates' interpersonal skills such as time management, teamwork skills, and self-efficacy, as well as had an impact on the graduates' STEM career choices. The main factors impacting the graduates' career choice was their exposure to robotics and to experts from the industry. The theoretical contribution is to the social cognitive theory (SCT) in the context of the FIRST program. Our study explains students' career choice through correlations among students' aspirations for choosing a career, their self-efficacy, their interpersonal skills, and their actual choice. The practical contribution lies in better understanding the robotic PBL program and expanding the STEM work force.

Keywords: STEM; project-based learning; self-efficacy; social cognitive theory; interpersonal skills; robotics; FIRST program

1. Introduction

Science, technology, engineering, and mathematics (STEM) education is crucial in the 21st century, considering the increasing global impact of technology. This section presents the theoretical background for research regarding STEM education, project-based learning, 21st century skills and robotics. We also discuss the aspect of self-efficacy, as part of the social cognitive theory.

There is an ever-increasing need for STEM professionals in the workforce in many countries [1,2]. Despite the high income that STEM occupations offer, there is a decrease in the number of students who pursue these domains [3,4]. Research suggests that teachers can foster their students' confidence in their STEM abilities, and this may have a positive effect on their self-efficacy regarding STEM and encourage them to choose STEM as an academic and career path. This implies that students' perceptions of their STEM abilities may be altered and are even more significant than their actual STEM abilities in determining their potential pursuit of a career in the STEM domain [5].

STEM education in Israel is ranked very high on the list of national priorities, and Israel as a "startup nation" focuses on the development of innovative technologies and engineering solutions [6]. Therefore, STEM education has become the focus of many public discussions. Students in Israeli secondary schools (grades 7–12) can study these domains at varying levels of difficulty, ranging from one unit for the lowest level to five units for the highest level [7]. Due to the correlation between the number of students who study high-level mathematics and the number of students who study STEM domains, the Israeli Ministry of Education allocated special funding and designed a mathematics strategy for increasing the number of high-school students who choose to study five units of mathematics [8].

Positive STEM learning experiences in secondary public schools in Israel are associated with students' interest in pursuing STEM domains. Studying advanced science courses at the secondary school level reduces the effect of family background on students' interest in pursuing STEM domains in the future, and it decreases the gender gap. Self-efficacy and outcome expectations positively correlate with the entrance of students into post-secondary education [9].

1.1. Project-Based Learning (PBL)

Project-based learning (PBL) is an active learning strategy that was addressed by Kilpatrick (1918) [10] and Dewey (1938) [11] in their description of the project method. Encouraging students to use active learning was presented as the first principle of the PBL method [12]. PBL in STEM was found to have a positive influence on students' attitudes toward learning, and to foster team communication and collaborative behavior [13,14]. In addition, PBL increases students' interest in STEM, and it builds their self-confidence and self-efficacy [15].

The program For Inspiration and Recognition of Science and Technology (FIRST) is based on PBL, an approach that exposes students to a real-world or authentic problems, offers a set of practical tools, and in STEM topics also involves creating an artifact [16]. The students learn new knowledge and skills as they build a prototype, such as a robot [12,17–19]. PBL focuses on problems and questions that encourage students to learn and find solutions using decision-making and problem-solving skills, autonomy, and responsibility [18,19]. The problems presented simulate real-world challenges from both daily life experiences and work environments. The learning process is done over a long period of time, and students improve their ability to acquire content knowledge and teamwork skills [17,20].

1.2. 21st Century Skills

General thinking skills and analytical–technical skills, which are necessary for learning STEM topics, are no longer enough in the 21st century. The definition of interpersonal skills has evolved over time and is inconclusive; however, there is no doubt that interpersonal skills are important for contending with the increased complexity of today's work environment [21–23].

The Accreditation Board for Engineering and Technology (ABET), an organization that accredits college and university programs in natural sciences, computing, engineering, and engineering technology, defined a set of "hard" engineering skills and a set of "soft" skills. "Soft" skills refer to interpersonal skills, including communication, teamwork, ethical understanding, professionalism, lifelong learning, and time management of self and group activities, as well as knowledge of contemporary issues within the global and societal contexts. In institutions where engineering design projects are commonplace, several innovative methods for teaching these skills have been adopted [24,25].

1.3. Robotics

Robotics has developed significantly in recent years and has gained popularity as an educational tool. During the last decade, teachers used robotics to develop students' cognitive and social skills to support STEM learning [26]. Educational robotics is a learning approach, which engages students in tangible, attractive activities that promote their curiosity [26–28]. As a result, high schools and universities develop robotics courses as part of their curriculum and as extracurricular activities. By building robots in teams, students can learn engineering skills such as teamwork skills, designing, and problem-solving. Using PBL in robotics helps improve the students' knowledge, while they gain the benefits of PBL [29,30].

Robotics projects that include problem-solving have a positive influence on participants' thinking skills and knowledge levels. High-level problem-solving abilities, improved thinking skills, increased knowledge, and more positive attitudes were shown to improve students' behavior. Improved understanding and gaining positive attitudes and values encourage students to participate in science and technology competitions [31].

Robotics projects have been found to improve creativity, problem-solving, and teamwork skills [32].

In a robotics competition for undergraduate students called IDC Robocon, the team members are students from different countries. The results of a study conducted on this robotics competition showed that transnational teaming triggered students' creativity and fostered their hands-on skills and understanding of curriculum knowledge [33].

Another robotic competition, the Trinity College Fire-Fighting Home Robot Contest Robotics Olympiad, offers junior-high and high-school students the opportunity to apply their skills by designing and developing autonomous robots. Participants completed a 50 min written examination that covered four areas: mechanics, sensors, software, and electronics. A study showed that this Olympiad achieved its primary goal: to foster and improve robotics education on an international scale [30]. Studying another Robotics Olympiad showed that an understanding of science and engineering concepts can be developed in the process of designing, building, and operating robots. Nevertheless, the students' level of comprehension depended on the educational process and differed between the teams [34].

1.4. Self-Efficacy and Its Purpose in Robotics Programs

The social cognitive theory (SCT) was presented by Bandura [35], who postulated that there are three themes that determine motivation and actions: personal cognitive, environmental, and behavioral themes [36]. In this study, we focused on self-efficacy as part of the personal theme.

Self-efficacy is one of the goals studied in this research. Following other studies, we attempted to understand the influence of self-efficacy on the participants in the FIRST program, regarding their performance in the program, and subsequent higher education and career choices. Students' self-efficacy regarding career choices and their occupation is determined by their perceived efficacy more than by their academic achievements [37].

It has been shown that team members with low self-efficacy have lower grades; this can be changed not with negative or positive comments, but with team members' or mentors' guidance. A team is not only a group of individuals who share a common goal, but also a social entity with social, emotional, and cognitive interactions. The notion that teamwork can support student learning if these interactions support self-efficacy was supported by the FIRST program activity [38]. Well-structured student teams engaged in an authentic engineering process are likely to construct high-value products [39]. Mentors who adopt this active learning approach promote their students' self-efficacy, outcome expectations, and interest [39,40].

In a study with pre-college students, the students who participated in a STEM competition were more interested in STEM careers at the end of high school than students who did not participate in these competitions, whereby participation apparently increased their interest. The competition had a greater impact on girls' interest in engineering careers compared to boys. Participating in a STEM competition had a positive effect on students' self-efficacy in STEM, particularly in the specific STEM subdiscipline of the competition, such as science, engineering, information technology (IT), or robotics [41].

In this section, we described the background and previous research that led us to define the goal of this research, namely, to characterize and evaluate the effect of the FIRST program on graduates' self-efficacy, interpersonal skills, and career choices in STEM.

2. Methods

The methods section describes the FIRST program, the research environment, the FIRST robotic competition (FRC) of 2020, the participants, research questions, research tools, data collection, and the analysis processes. We start this section with a description of the FIRST program, which was founded in 1989 in the United States of America (USA) as a nonprofit organization, by Dean Kamen, an engineer, inventor, and businessman. The program aims to motivate young people to pursue education and career opportunities in STEM, while building self-efficacy, knowledge, and life skills. The program incorporates PBL and fosters innovative robotics design and production. Evaluations of the FIRST program in the USA showed an increase in participants' interest in STEM, understanding of STEM, and STEM career choices [41–43]. Students' STEM knowledge increases when they participate in the program over a period of several years [44].

The vision of FIRST Israel, founded in 2005, is to be a significant organization that exposes students to STEM while developing and maintaining a valuable organizational and social culture [45]. Over 12,000 students aged 5–18 years participate in FIRST Israel activities each year.

In light of the findings from the FIRST USA studies [41–43], it is important to investigate similarities and differences between the impact of FIRST on participants in the USA and those in Israel, and to identify which of these differences, if any, relate to cultural and societal backgrounds.

2.1. Research Environment

Innovative robotics programs are characterized by robotics challenges that involve the students in community service activities [44]. Every year, global competitions are held in which teams of young adults and their robots play a field game against other teams (e.g., throwing balls into a basket). The theme of the game changes each year. Students must develop STEM skills and apply engineering principles while realizing the value of hard work, innovation, and working as a team. The teams are guided by professional mentors, most of whom are volunteers. Each season ends with a global FIRST Championship. The competitions are held according to the level and age of the students, in four leagues. Figure 1 shows an example of a robot developed for a high-school league FRC [40,42].

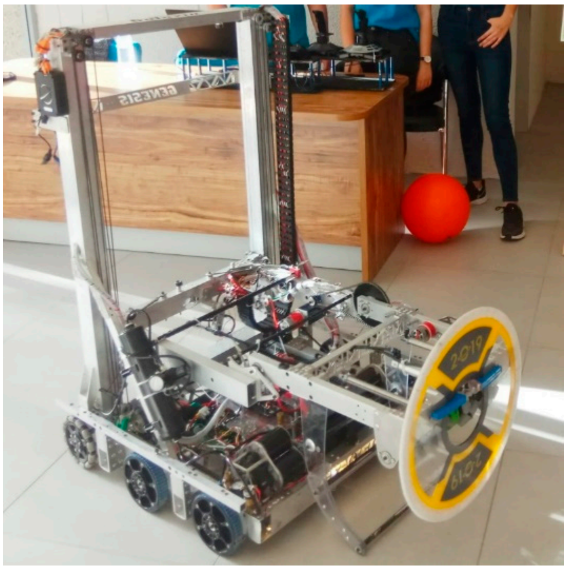

Figure 1. For Inspiration and Recognition of Science and Technology (FIRST) Robotic Competition (FRC)—robot developed by team 5987.

Teams are challenged to raise funds, create a design using teamwork skills, build a robot, use computer animations, and program industrial-size robots to play against competitors. Awards are given to teams for several categories, including design, website, engineering inspiration, and robot performance. The most prestigious award is the Chairman's Award, which honors the team that best inspires the other teams to appreciate science and technology, and encourages young people to become science and technology leaders [42].

FIRST activities are based on the involvement of volunteers who are part of the FIRST community. The volunteers participate in activities and competitions, which include about 50 events held each year. Approximately 12,000 students in Israel participate in this program in more than 1200 groups [43]. In our study, we focus mainly on the FIRST Robotics Competition (FRC), a high-school robotics program with strict rules, limited resources, and a 6 week time limit. Figure 1 shows an example of a robot that competed in the 2019 FRC, built by team 5987 from a city located in northern Israel.

FIRST Robotic Competition (FRC), 2020 Season

We interviewed AMVS01 (a code of the interviewee), a graduate of FIRST, who continues to contribute to the program as a mentor and a judge in competitions. Below is an excerpt from her interview. The purpose of the quote of this interview is to show the atmosphere of the FIRST competition, in the eyes of a graduate, who later served as a mentor and judge.

"The competition itself is a real festival. Although the last competition I participated in as a student was a few years ago, the excitement of every game and every victory or loss of the team I grew up in makes me feel joy or disappointment.

As an observer, I have noticed that the Israeli teams have become more professional over the years, and that FIRST succeeds each year in inventing a new and challenging game. The robots look more professional and more durable, and there are fewer malfunctions on the field. On the technological level, there have been significant improvements, especially to the control systems and software, and, as expected, the game is getting more impressive. In addition, looking in the 'pits' (the groups' work areas), I was impressed by the community activities of the different groups . . .

The Technion awards a number of scholarships to 12th graders who are in the final year of participating in the program as students. This year, I volunteered to interview some of the scholarship applicants . . . Each student I interviewed was more impressive than the other, with a fascinating personal story. They have a gleam in their eyes and a desire to continue to experience new technological and social challenges such as the annual FRC. I met brilliant high-school students with great technological ideas, and their charismatic leaders who led the team members in a social and professional way."

2.2. Research Questions

Our research questions were as follows:

(a) Do the FIRST program activities in Israel foster self-efficacy and interpersonal skills, such as teamwork, communication, and leadership among its graduates, and, if so, how?

(b) Do FIRST participants choose to study STEM domains at universities and pursue a STEM career? What are the factors that affect these choices?

2.3. Participants

The participants in this research are graduates of the FIRST program, aged 18–30, including recent high-school graduates, young adults performing their compulsory military duty, students from universities and colleges, and some who already had a career. A graduate of the FIRST program is a high-school student after his 12th grade, who participated in FIRST activity for at least the last two years of their high school. Each graduate can start in a different grade, may participate in local and national competitions, and has different roles in the team. Some of the graduates are also mentors and volunteers at FIRST. There were 297 participants who filled out a questionnaire, five of whom were interviewed. The FIRST graduates that responded to the questionnaire volunteered to participate in our study in response to the request on social media run by FIRST. We cannot tell the exact response rate because (a) not all graduates are on social media run by FIRST, and (b) due to privacy issues, we could not get the list of the graduates and, therefore, we could not send personal request.

Distributions of the participants' demographics are presented in Table 1. According to the data, 67% of those who filled out the questionnaires were between 18–21 years old.

Table 1. Demographics of the participants who filled in questionnaires and were interviewed, by age and gender.

Research Tool	$N_{participants}$	Age	Male %	Female %
Questionnaire	200	18–21	75	25
	65	22–25	66	34
	32	26–30	84	16
Interview	5	20–27	60	40

2.4. Research Tools

The research tools included online questionnaires and semi-structured interviews.

2.4.1. Questionnaires

The questionnaires include closed- and open-ended questions, which were composed in parallel to the interviewing process. The closed-ended questions were statements ranked on a 1–5 Likert scale, where 5 meant "strongly agrees" and 1 meant "totally disagrees".

The questionnaire was divided into two parts:

Part A: Demographic and personal data, including information about gender, age, high-school major, the geographic area where the FIRST activity takes place, and type of STEM education, if any.

Part B: Professional and social contributions, including 31 statements for all participants to rate on a Likert scale ranging from 1–5, seven statements only for graduates of the program who are also mentors, six statements for students who received Technion scholarships, and six open-ended questions. Some questions in the questionnaire for the graduates were focused on the influence of the participation in the FIRST program on their career choice. In addition, the graduates were asked to report both their major domain in high school and their actual choice at the university, as well as their career (if they already had one). The statements in part B were designed on the basis of previous studies done with FIRST participants in the USA and with Israeli participants in other projects [4,42,46]. One example of a statement is the following: "Participation in the project improved my teamwork skills".

One example of an open-ended question is the following: "What do you think is the major impact that the FIRST program had on you?"

The statements in part B of all the questionnaires included the three SCT themes [35]. The statements were designed on the basis of previous studies done with FIRST participants in the USA and with Israeli participants in other projects [4,42,46]. Examples of statements by themes are presented below.

Personal theme:

- Participation in the program improved my belief in myself and my abilities.
- Participation in the project improved my teamwork skills.
- Participation in the project improved my learning skills.

Environmental theme:

- My parents supported my participation in the program.
- My school management supported my participation in the program.
- When I joined the group, the program was considered cool at my school or by my friends.

Behavioral theme:

- My experience with the FIRST program has influenced my career choice.

- Acquaintance with the industry people made me want to study a science or technology profession.
- I used the professional knowledge I learned in the program in the military, work, high school or my daily life.

2.4.2. Interviews

Semi-structured 1 h interviews were conducted with five FIRST graduates. The questions were prepared in advance and modified according to the interviewees' answers and their relation to the program. We guaranteed complete anonymity and confidentiality of the interviews, which were done face-to-face or using conference calls. The interviews were audio-recorded with the participants' permission, transcribed, and qualitatively analyzed by four STEM educators—the four authors of this paper—a senior faculty member, a researcher, a PhD student, and a FIRST program mentor undergraduate student.

Some examples of interview questions are the following:

(a) How did you become involved in the FIRST project?
(b) Describe your role at FIRST.
(c) What pros and cons do you see in the project?
(d) Where do you see yourself in 5–10 years from now?

2.5. Data Collection and Analysis

Data collection and analysis were based on the convergence model, as shown in Table 2. We started the data collection by interviewing FIRST graduates while developing the questionnaire in parallel. We continued to interview the FIRST graduates and analyze the data from the interviews, as described in Section 2.5.2. At that time, we also administered the questionnaires and analyzed the data, as described in Section 2.5.1.

Table 2. Triangulation design: convergence model [47].

The Stage of the Research Methodology	Quantitative-Questionnaires	Qualitative-Interviews
Data collection	+	+
Data analysis	+	+
Results	+	+
Compare and Contrast	+	
Interpretation	+	

Having obtained the data analysis results of the five interviews and 297 questionnaire responses, we combined, compared, and contrasted these results to achieve a comprehensive answer to our research questions.

2.5.1. Data Collection and Analysis—Questionnaires

The questionnaires were created using Google forms and then administered to FIRST graduates via Facebook, WhatsApp, and email to FIRST management (see examples in Table 3).

We received 297 responses and collected the data from these graduates' questionnaires. We carried out exploratory factor analysis (EFA) to identify the factors of 31 statements. In order to find the best factors for this study, we checked six- and five-factor analyses, using principal component analysis with varimax rotation. Eventually, five-factor analysis was found to be best for all 31 statements in the graduates' questionnaire, with a total reliability of $\alpha = 0.802$.

Table 3 presents the five factors, their reliability, and an example statement for each category.

Table 3. Factor analysis of the graduates' questionnaire. STEM, science, technology, engineering, and mathematics.

Theme	Category	*N* Items	Cronbach's Alpha	Example of an Item
Behavioral	Contribution of the FIRST program to developing soft skills	10	0.846	Participating in the program improved my management and leadership skills.
Behavioral	Impact of the FIRST program on career choice	6	0.782	My work during my military service after participating in the program was directed toward science and technology thanks to my participation in the FIRST program.
Environmental	Support from family and friends	6	0.576	Participation in the FIRST program is a source of pride for my family.
Environmental	STEM exposure and teacher support	5	0.564	Exposure to the technological world in the FIRST program opened up a new world to me that I did not know about it before.
Personal	Motivation	4	0.477	When I joined the group, the program was considered cool at my school/among my friends.
Total		31	0.802	

2.5.2. Data Collection and Analysis—Interviews

Data collection and analysis of the interviews was done by recording the interviews and transcribing them. Each transcribed interview was broken down into statements, each focusing on a single idea. The statements were grouped into one of the three main themes described in the SCT (personal, environmental, and behavioral), and then assigned to a relevant category. To ensure that the category classification was correct, we compared 20% of the statements for each category with the classifications of four inter-judges. The agreement percentage of the four inter-judges was 90.7%, with kappa = 0.828.

We identified 14 categories: six in the environmental theme, four in the personal theme, and four in the behavioral theme. Examples of statements for each theme are presented in Table 4. Most of the categories included positive and negative examples, and we marked the negative ones in gray. We calculated the percentage of statements in each category for each interviewee and in total.

Table 4. Examples of statements for each theme.

Theme	Category	Statement	Interviewee
Personal	Self-efficacy—scientific learning (interest, responsibility, enjoyment)	You can learn ... There are no limits to the amount of knowledge you can accumulate. It is really up to you. You will be curious and interested simply to learn more and more. It can be unprofessional; it really depends on the child and the group.	AMS01A graduate and mentor
Personal	Self-confidence	FIRST made me realize that the sky is the limit. Willpower and perseverance are key.	AMV01 A graduate, volunteer and mentor
Environmental	Extrinsic motivation—rewards/status/prestige	Every year, 3–4 scholarships are awarded. That's nothing, and why only from the Technion? Why do other universities not also contribute to this program?	AMS02 A graduate and mentor
Environmental	Perceptions and stigmas regarding STEM	The difference in the stigma is that girls do not fit into the technology domain and what we see in FIRST is the opposite, that girls are better suited than boys.	L03 Director
Behavioral	Opportunities and limitations	The biggest downside of FIRST ... Umm ... The price, I think. [Laughs] Because it does not allow anyone to start a group, and I think there is too much fuss about the issue.	AMS03 A graduate and mentor
Behavioral	Mentor/team leader/volunteer—behavioral and social guidance	In the end, I was in charge of the group; that is what I did ... I was their mom and dad on the team; that was the most important role.	MT01 A mentor

2.6. Ethics

The research was approved by the Technion Ethics Committee, approval number 2019-020.

3. Results

This section reviews the analysis results on the basis of data collected from 297 questionnaires of FIRST graduates and five interviews with the graduates; the results for each research question are presented.

3.1. Do the FIRST Program Activities in Israel Foster the Development of Self-Efficacy and Interpersonal Skills, Such as Teamwork, Communication, and Leadership among Its Graduates and, If So, How?

Following the factor analysis of the graduates' questionnaires, as described in Table 3, we checked the percentage of graduates who reported a high influence for the program (4 on Likert scale) and very high influence (5 on Likert scale) in the questionnaire. The data are presented in Table 5.

The data in Table 5 show that the FIRST program had a very strong influence on the participants' academic choices.

Table 5. Questionnaire categories: descriptive statistics.

Category	*N* Items	Mean	Standard Deviation	% very High	% High
Contribution of the *FIRST* program to developing interpersonal skills	10	4.14	0.96	45%	33%
Impact of the *FIRST* program on career choice	6	3.6	1.3	33%	26%
Support from family and friends	6	3.75	1.43	46%	18%
STEM exposure and support from teachers	5	3.37	1.43	30%	23%
Motivation	4	3.05	1.29	15%	26%

The influence described was the result of the exposure to the program and familiarity with the high-tech industry. In addition, exposure to STEM domains helped graduates focus on a particular domain of STEM, even among those who showed preferences for STEM domains before joining the program. Furthermore, most graduates (78%) noted that participation in the program had improved interpersonal skills such as time management, speaking in front of an audience, teamwork, and coping with pressure. Regarding their participation in the program, most of the graduates (64%) indicated that their families provided a supportive environment, and that participation in the program was a source of personal and family pride.

The five interviews were analyzed by dividing the interviews into 419 statements, and coding the statements according to the environmental, personal, and behavioral themes. Later, the statements were coded by categories within each theme according to categories that served us in a previous study [4], as shown in Table 6. We also identified new categories which focus on mentors/team leaders/volunteers, i.e., the new categories shaded in gray in Table 6.

The distribution of the statements between the three themes is presented in Figure 2. Most of the statements were related to the environmental theme, as shown in Figures 3 and 4.

Table 6. Category for each theme new categories shaded in gray.

Category	Theme
The influence of educational programs on choosing a STEM career	Environmental
Influence of teachers and schools	
Family and friends	
Extrinsic motivation: rewards/status/prestige	
Perceptions and stigmas regarding STEM	
Influence of mentors/parents/team leaders	
Self-efficacy: scientific learning (interest, responsibility, enjoyment)	Personal
Self-efficacy: task-oriented	
Self-confidence	
The quality of the students	
Exposure	Behavioral
Opportunities vs. limitations	
Mentor/team leader/volunteer: professional tasks	
Mentor/team leader/volunteer: behavioral and social guidance	

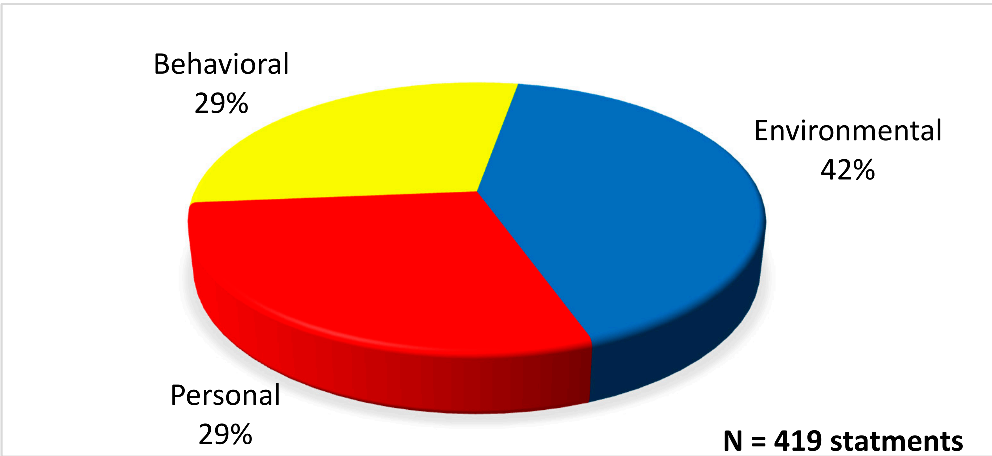

Figure 2. Distribution of statements from interviews by theme.

Figures 3 and 4 show the distribution of the categories in each of the themes. We decided to present only the categories that constituted over 15% of the statements in that theme. Figure 3 shows that most of the statements in the environmental theme were related to the influence of educational programs on choosing STEM careers or to extrinsic motivation such as rewards, status, or prestige. The "others" category included several statements related to different categories, such as "I would also like to have more woman mentors for software, drawing, and engineering. I wish these things would happen." (AMVS02, line 51, male, age 24, mentor).

Figure 4 presents the distribution of categories in the personal and behavioral themes. The personal theme shows that most of the statements referred to self-efficacy of scientific learning regarding interest, responsibility, and enjoyment. Most of the statements in the behavioral theme were related to the professional, behavioral, and social guidance of the mentor, team leader, or other volunteers in the FIRST program.

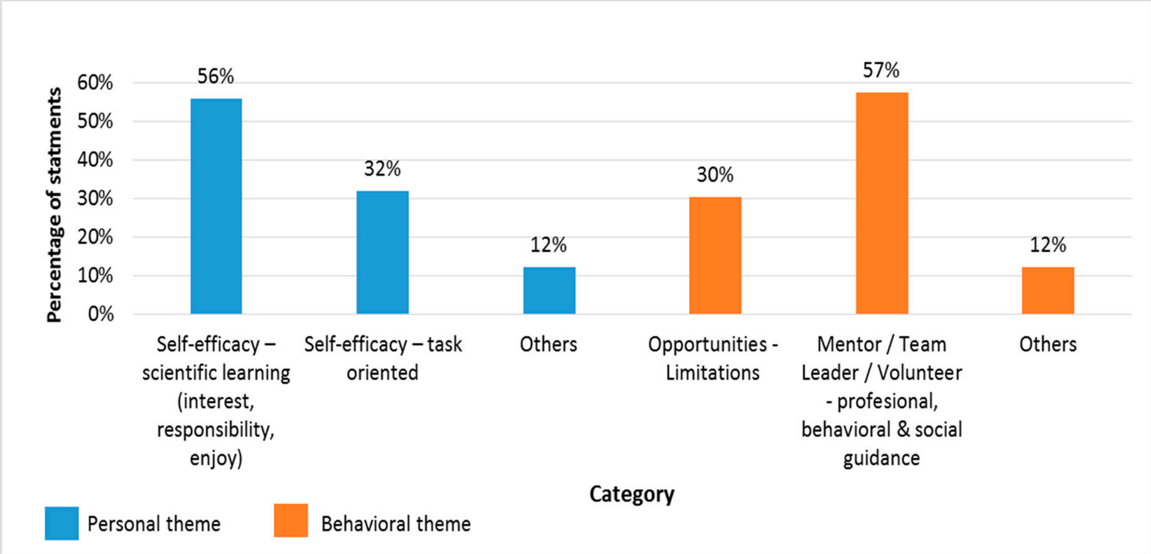

Figure 3. Distribution of categories in the environmental theme.

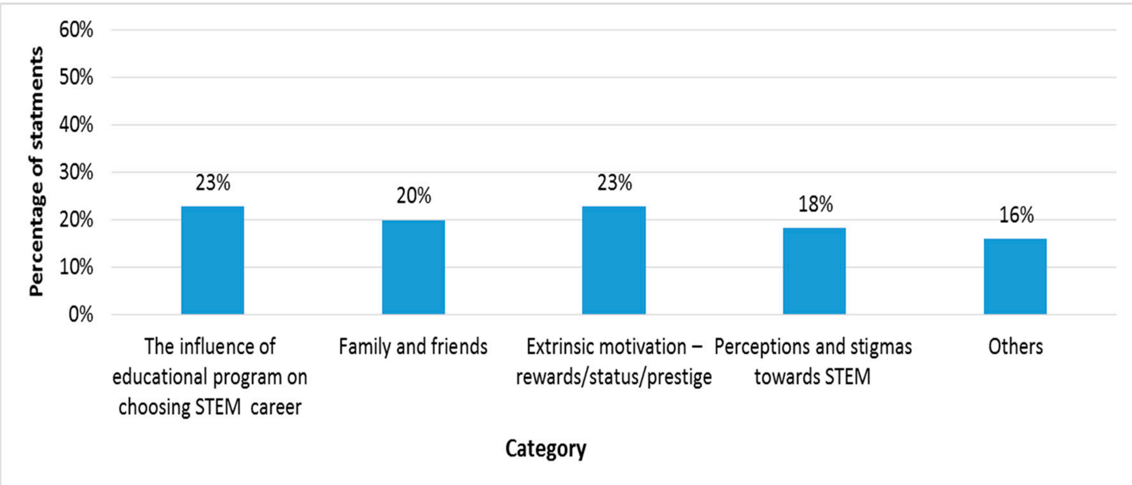

Figure 4. Distribution of categories in the personal and behavioral themes.

Some examples of statements from the interviews are cited below, to demonstrate how FIRST program activities in Israel foster the development of self-efficacy and interpersonal skills.

Interviewer's question: "Are there other values, like not being afraid of criticism while learning?" The interviewees' responses are described below.

"Teamwork, that is above all. That I am not alone here and if, sometimes, I want to do something by myself ... It is not the right thing to do, and I work here with the group. On the other hand, although we are a group, I need to stand up for myself and not give in. Do not come and say well someone else wants to do something different so let us listen to him and not listen to me at all." (AS01 line 85, female, age 20, volunteer as head of the alumni organization).

"I admit that my best friends are from FIRST. It is a place to escape. I can testify it is some kind of refuge for me ... All my best friends are from FIRST." (AMVS02, line 54, male, age 24, mentor).

"The experience of volunteering, doing something else in your life that is significant. For me, volunteering means doing more things in my life. For me, life without doing, and I found that in FIRST too, means nothing if I do not work, do not do, do not study." (AMVS02, line 64, male, age 24, mentor).

"Values beyond the learning itself, values of helping, respect for others ... If it is a group made up of both religious and nonreligious students, then to know each other, to give other people a place, to respect a person's choices." (AMS04, line 47, male, age 26, mentor).

"For the girls, I think, it mostly gave them independence; they felt they could build something themselves, do something; they did not need a man to open a can or jar for them; they could do it alone. Feeling capable, feeling able, in terms of success even if they do not go to the next stage, but the fact that they are building something that is suddenly moving is crazy. "(AMS04, line 49, male, age 26, mentor).

3.2. Do FIRST Participants Choose to Study STEM at Universities and Pursue STEM Careers? What Are the Factors That Affect These Choices?

To answer this research question, we analyzed the data from the questionnaires regarding the graduates' majors in high school and their current occupation. Some questions and statements in the questionnaire relate to participants' career choice preferences before and after participating in FIRST. Examples are the following: (1) "The experience at the FIRST program has influenced my career choice." (2) "To what extent did your participation in the FIRST project have an impact on the choice of your course of study? Please elaborate."

At the beginning, we checked if the graduates chose to study a STEM domain, non-STEM domain, or both in high school, and whether or not their current occupation is related to STEM. The results presented in Figure 5a show the choices of high-school students. The percentage of students who chose to study STEM in high school was significantly higher (88%) than students who chose non-STEM domains. We found that 10% of the graduates chose both STEM and non-STEM domains as their high-school majors.

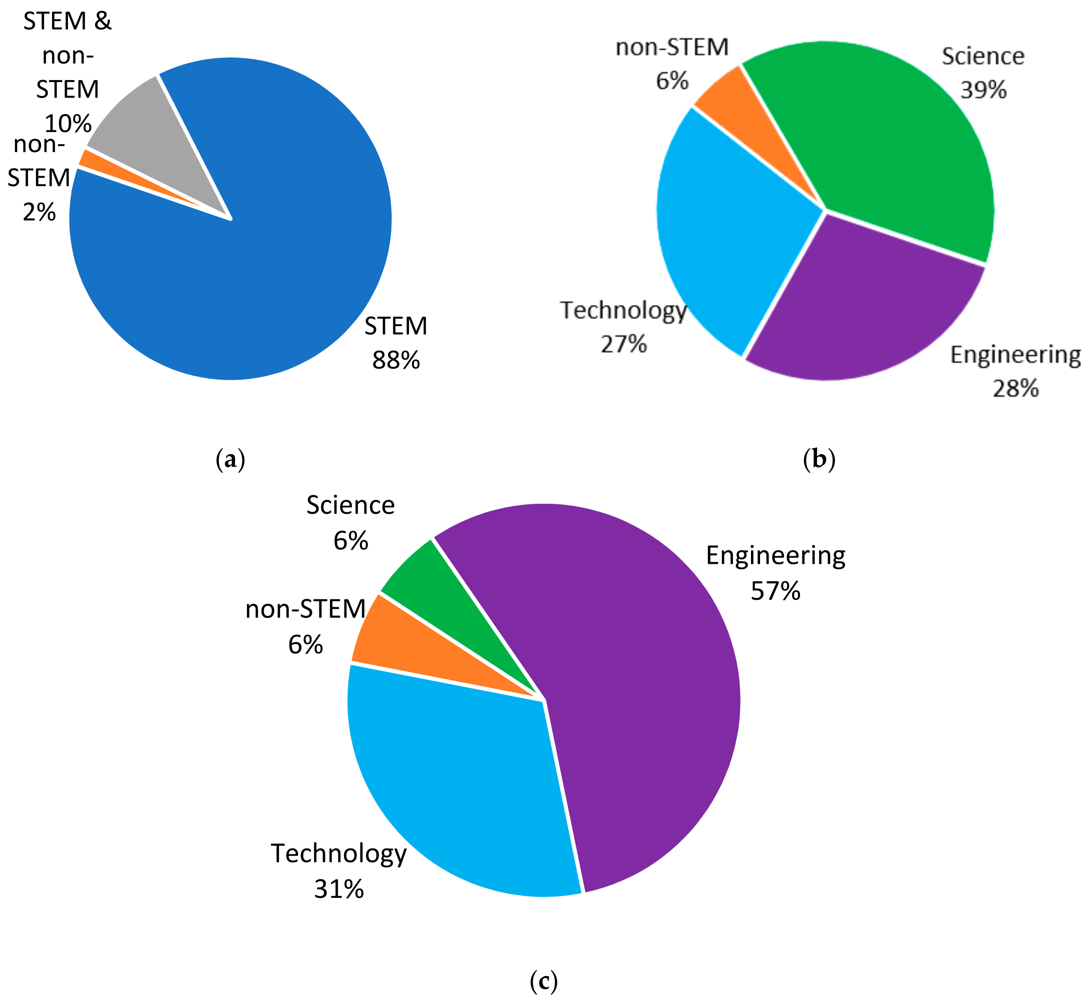

Figure 5. STEM and non-STEM distribution of the responders' majors in high school and their current occupation. (**a**) High-school majors. (**b**) High-school majors: STEM domains. (**c**) Current status: within STEM domains.

We divided the domains that the participants chose as high-school majors according to the acronym STEM—science, technology, engineering, and mathematics. Science represents biology, chemistry, physics, neuroscience, medicine, and food science. Technology represents robotics, biotechnology, technological sciences, and mechatronics. Engineering represents electronics, software engineering, computer science, cyber, aeronautics, electrical engineering, and mechanical engineering. Mathematics represents economics, mathematics and statistics.

Figure 5b presents the distribution of the high-school majors between science, engineering, technology, and non-STEM. Mathematics is not presented in this figure because, in the Israeli education system, all students who choose to major in science, engineering, or technology also learn mathematics at a high level (similar to A or A+). In addition, most of the students (75%) chose more than one major in high school. As shown in Figure 5b, most of the graduates majored in science (39%), while others chose engineering (28%) or technology (27%).

When we checked the distribution of STEM domains in the participants' current occupation (work or academic studies), as shown in Figure 5c, we saw that most of the graduates currently study or work in engineering-related domains (57%). Other graduates chose technology as their profession (31%), whereas only 6% study or work in science-related domains.

We present some examples below of statements that the interviewees noted in order to explain the factors that affect their choices of STEM careers.

"I think personally ... I received a lot of things that are technical from FIRST. In addition to self-confidence ... The knowledge that I want to get involved mechanical engineering; but what kept me in FIRST are my friends. Because if I did not connect with people, I would not go." (AS01, Line 111, female, age 20, volunteer).

"I really like the program ... it is one of the most fun things I have ever done ... It is a very fun way to deal with technology and science." (AMS01, line 16, female, age 24, mentor).

"So, it always attracted me. I think that FIRST may have helped me focus on ... technology and not physics or biology or anything like that." (AMS01, line 23, female, age 24, mentor).

"What we really did is one of the big advantages of FIRST compared to other programming projects, which are no less instructive and maybe even more so, because you have a real product and not just code; something that really moves, it is very good for attracting people. That was one of Dean Kamen's original goals; that is why he uses robots." (AMV03, line 21, male, age 24, volunteer).

"My ambition is to engage the students and foster their love toward science and physics from the lower grades." (AMS04, line 26, male, age 26, mentor).

"Of course, giving the students tools to help them in the future, everything is robotic. All the girls who joined the army, when they said they were in robotics, the military offered them really, really meaningful roles. And this, too, for life in general, I think it gives them some sort of glimpse into programming or knowing a programming language; if it is mechanics that you studied, in adulthood, it can open up an opportunity to study mechatronics or machines as well, at least get the basics." (AMS04, line 48, male, age 26, mentor).

4. Discussion

In order to characterize and evaluate the effect of the FIRST program on graduates' self-efficacy, interpersonal skills, and career choices in STEM, we divided the discussion into two sections according to each research question and the results presented above.

4.1. Do the FIRST Program Activities in Israel Foster the Development of Self-Efficacy and Interpersonal Skills?

The main finding from the questionnaires was that the graduates reported that the FIRST program had a strong influence on improving interpersonal skills and self-efficacy (see Table 5 and Figure 3 in Section 3.1). The results demonstrated the power of a supportive family and showed that the program was a source of personal pride. These findings strengthen previous research [13–15] about PBL and robotic activities, which found a positive influence on self-confidence, communication, self-efficacy, creativity, leadership, problem-solving, and teamwork skills.

The distribution of statements from the interviews by theme shows that most of the statements were related to the environmental theme rather than to the personal and behavioral themes. In the environmental theme, statements regarding the influence of the educational program on choosing STEM careers and extrinsic motivation (rewards/status/prestige) were the most common. These findings reinforce the results of previous SCT studies [38] that showed that environmental factors have a stronger effect than personal or behavioral factors.

In the personal theme, most of the statements were related to self-efficacy of scientific learning regarding interest, responsibility, and enjoyment. This coincides with other studies on participation in STEM competitions and in STEM PBL that showed a positive effect on students' self-efficacy of STEM [31,41].

Most of the statements in the behavioral theme were related to the social guidance of the mentor, team leader, or other volunteers in the FIRST program. This finding demonstrates the strong influence that mentors have on their students, and can explain why so many participants in FIRST become mentors either as members or after they graduate.

4.2. Do FIRST Participants Choose to Study STEM Domains in University and Pursue STEM Careers? What Are the Factors that Affect these Choices?

The main results in the questionnaire and interviews showed that the FIRST program had a strong influence on students' decision to study STEM domains. These results support and strengthen previous research outcomes [29–32], which indicated that participation in robotics competitions increase interpersonal skills and promote career choice in a STEM domain.

The exposure to STEM during the FIRST activities influenced the graduates' choice to study STEM in high school much more (88%) than the percentage of students who chose non-STEM subjects (2%). However, when comparing FIRST graduates' choices with high-school students' choices, we might see not only similar patterns but also the impact of the program on the graduates' career choices. When choosing a career or profession, most FIRST graduates (94%) chose STEM domains. The graduates' choices also demonstrate their practical choices, as the majority are currently employed as engineers (57%) or in technology-related professions (31%).

Over the years, the choice of high-school students to major in STEM has been decreasing. Data from the Israeli Central Bureau of Statistics show the decline in choosing STEM as a major at the high-school and university levels. For example, in 2017, 47.6% of high-school students chose STEM as a major, compared with 98% of the FIRST participants who declared that they chose STEM as their major. In 2016, only 22.7% of the university students chose a STEM discipline, compared with 94% of the FIRST graduates who declared that they study or work in a STEM discipline [4]. The high percentage of FIRST program's graduates who choose STEM as a career may expand the STEM work force.

The interviews showed that the statements regarding STEM choices were related to the environmental and personal themes. In the environmental theme, the statements were related to the influence of the educational program on choosing a STEM career, as well as to perceptions and stigmas regarding STEM. In the personal theme, the statements were related to self-efficacy of scientific learning (interest, responsibility, enjoyment).

4.3. Research Limitation and Contributions

The limitation of this study is that it reflects the perceptions of a specific group of FIRST participants, without a control group of subjects who did not participate in FIRST or who participated in other STEM or non-STEM programs. Nevertheless, this study can contribute to understanding young people's STEM career choices.

The theoretical contribution of this study is its novel analysis, to the best of our knowledge, using the SCT theory in the context of the FIRST program. In addition, it expands the theoretical knowledge by introducing new categories about the mentor, team leader, or volunteer, regarding their influence, professional tasks, and behavioral and social guidance.

On the practical level, this study can be presented to stakeholders to demonstrate the impact of the program as a robotic PBL program on expanding the STEM workforce, which is in constant need of human capital.

The methodological contribution is the validation of the questionnaire through factor analysis, which makes the questionnaire accessible to researchers who wish to use it as a reliable tool in relevant studies.

5. Conclusions

The FIRST robotic program succeeds in motivating students to pursue education and career opportunities in STEM domains, to increase self-efficacy, and to gain interpersonal skills. The program manages to motivate students by exposing them to STEM and robotics, exciting them with competitions, and inspiring them with their mentors' guidance.

The graduates become better people in many aspects, and the program can have a positive influence on its participants and their communities. If the program receives the support it needs to grow and expand, it can help develop many of Israel's needs as a startup nation.

For future research, it would be interesting to further examine the influence of mentors on students in the FIRST program, as demonstrated in our results. Additional research can include investigation of high-school students while they are participating in *FIRST* activities.

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