J Sci Educ Technol (2014) 23:549–561
DOI 10.1007/s10956-014-9487-7

Encouraging Girls into Science and Technology with Feminine Role Model: Does This Work?

Yael M. Bamberger

Published online: 5 March 2014

Abstract This study examines the effect of a program that aimed to encourage girls to choose a science, technology, engineering, and mathematics (STEM) career in Israel. The program involved school visits to a high-tech company and meeting with role model female scientists. Sixty ninth-grade female students from a Jewish modern-orthodox single-sex secondary school in the same city as the company participated in the study. The control group contained 30 girls from the same classes who did not participate in the program. Data were collected through pre-post questionnaires, observations, and focus group interviews. It was analyzed for three main themes: perceptions of scientists and engineers, capability of dealing with STEM, and future career choice. Findings indicated respect toward the women scientists as being smart and creative, but significant negative change on the perceptions of women scientists/engineers, the capability of dealing with STEM, and the STEM career choices. Possible causes for these results are discussed, as well as implications for education.

Keywords Gender · STEM education · Role model · Informal learning

Introduction

For several years, educators have been worried about the relatively small number of students in general, and girls in particular, who choose science and technology in high school and undergraduate programs (Holmegaard et al. 2012). Research has shown the reasons for the lack of girls in science, technology, engineering, and mathematics (STEM). These reasons are indicated by factors such as different parents' and teachers' expectations of boys and girls, gender differences in learning styles, and different profession choices (Osborne et al. 2003; Zohar and Sela 2002).

In addition, researchers point out gender differences in attitudes toward science and scientists, in all grade levels (Jones et al. 2000; Weinburgh 1995). Girls tend to percept science and its relevance to their life in a less positive way than boys (Chetcuti and Kioko 2012; Zohar and Sela 2002). This phenomenon is even stronger in relation to physics and engineering, since these subjects are considered to be masculine areas, by both girls and boys (Farenga and Joyce 1999). According to that view, girl students tend to believe that they are not capable of working in such professions in the future (Christidou 2011; Haussler and Hoffmann 2002; Murphy and Whitelegg 2006; Osborne and Collins 2001).

For these reasons, girls tend to avoid pursuing STEM career. A recent national report of the Israel Ministry of Science, Technology, and Space (2013) reports the proportion of female high school students in science major topics: 30 % in physics and computing, and 63 % in biology. Another recent report of the Israel Central Bureau of Statistics describes the representation of women in undergraduate studies. In 2012, the subject areas in which women were less represented (fewer than 32 %) were mathematics, statistics, computing science, and engineering and architecture (Israel Central Bureau of Statistics 2013a). During that year, women in Israel were 48.6 % of the academic professions, but only 36.6 % in the high-technology industry. For comparison, in the USA, during 2009–2010, the percent of women who earned a bachelor

Y. M. Bamberger (✉)
Jerusalem College, P.O.B. 16078,
91160 Bayit Vegan, Jerusalem, Israel
e-mail: yael.bamberger@weizmann.ac.il;
yael.bamberger@gmail.com

degree in architecture 43 %, in computing science 19 %, and in engineering 17 % (National Center for Education Statistics 2011).

A European Union report describes the situation in Israel in terms of the proportion of female who graduated PhD in science and engineering. In 2003, the proportion of female PhD (ISCED 6) graduated in science, mathematics, and computing was 44 %, in engineering was 25 %, while, in social science the proportion was of 51 % (European Commission 2006). For comparison, on the same report, in the USA, the proportion of women in science was 35 % and in engineering 18 %, and in UK 42 and 19 %, respectively.

Consequently, in 2004, the Israeli Ministry of Education announced the BAMOT (acronym of Girls for Science and Technology, in Hebrew) project, aiming to encourage female students to choose science and technology by using the collaboration of secondary schools and high-tech industry companies. Through this project, high-tech companies invited local secondary schools to have girl students visit their company and meet with role model female scientists.

This study describes the results of the BAMOT project in one of the biggest high-tech companies in Israel. The company responded to the Ministry of Education challenge, and for a few years have arranged for female students to meet with leading women scientists. Through lectures and tours in laboratories, the students were exposed to the women's work.

What is the effect of these visits? Do they succeed in encouraging girls to choose a scientific career? These questions are the basis of this study.

Theoretical Framework

Girls and STEM: The Socio-Cultural Perspective

This study is framed on the socio-cultural perspective, which emphasizes the social nature of learning that occurs in a cultural context. Vygotsky (1978) asserts that social interactions and cultural symbols provide essential opportunities for constructing meanings, with the cultural context influencing one's perceptions of professions. Some markers of culture that can influence girls' participation in science are discussed in the following: nationality, gender, and religious and community values.

Nationality

Girls' participation in science can be influenced by the national culture of professions. Research has shown that in the USA and Europe, students' job aspirations still reflect the traditional men and women employment patterns (Archer et al. 2012; Murphy and Whitelegg 2006). In contrast, in a different culture in Kenya, girl students were very positive toward science and future STEM careers (Chetcuti and Kioko 2012). Therefore, the discussion on STEM careers for women should take into account the national cultural context.

Gender

Girls' participation in science is highly influenced by their gender identity which is shaped by the culture. Through middle school age, students start to connect professions to gender identity (Fung 2002). Physical science and engineering are perceived as masculine disciplines, in both boys' and girls' views (Farenga and Joyce 1999). The draw-a-scientist-test (DAST), which initially developed by Chambers (1983), asks students to draw a scientist. For years, most girls and boys draw a scientist as a man (Boylan et al. 1992; Chambers 1983; Finson 2003) and reflect their view as science as a masculine discipline. However, girls are more likely to draw female scientists, but they ask for permission to do so (Losh et al. 2008; Manzoli et al. 2006).

Religious and Community Values

Girls' participation in science can be influenced by their religious believes. In general, science and religion have dynamic relations for hundreds of years. Stenmark (2004) defined four possible relations between science and religion: social (practitioners' social interactions), teleological (aims the practitioners have in mind), epistemological (theories, methods, and beliefs), and theoretical (subject matter and content). In the context of this paper, only the epistemological relations between science and the Judaism religion will be discussed. The modern-orthodox stream of the Judaism praises in attempts to synthesize Jewish values with the modern world. A significant amount of scientists in Israel defines themselves as belong to the modern-orthodox Judaism, including the 2005 economic sciences Nobel Prize winner Prof. Robert Aumann. However, the centrality of values such as family and children education might collide with intensive career of women. Modern-orthodox females need to cope with this complexity much more than men (Bandel 2013).

The socio-cultural perspective deals with the ways cultural values, concepts and methods are being transferred. Teachers and parents are social agents that transfer the messages of the culture. In the case of the current study, these social agents frequently communicate, explicitly or implicitly, different expectations from boys to girls in terms of a STEM career (Archer et al. 2012; Mujtaba and Reiss 2012). In addition, the socio-cultural perspective highlights that formal as well as informal learning accrues in a social context, where students interact with each other and influence each other's ideas. In the case of this study, students influence each other's ideas about the capability of boys and girls in dealing with science and of having a future STEM career.

In addition, cultural ideas can be transferred through daily activities and practices. Family discussions about scientific issues in the news, visits in museums, or other leisure time activities that influence the girls' perceptions on science. When these activities involve women, it can also have an impact on the girls' perceptions on women scientists (Betz 1994; Quimby and DeSantis 2006).

Girls and STEM: Perceptions, Capability, and Choices

For several decades, researchers have discussed gender differences in relation to STEM. The differences still exist in students' perceptions of science and scientists, on their capability of dealing with science, and their career choices, as described here.

Perceptions of Science

Boys tend to percept science in a more positive way than girls and as more relevant to their life through all age groups (Chetcuti and Kioko 2012; Farenga and Joyce 1999; Jones et al. 2000; Jovanovic and King 1998; Osborne et al. 2003; Schreiner and Sjøberg 2007;Zohar and Sela 2002). In 1975, Gardner (1975) claimed that the gender is "probably the most significant variable related toward pupils' attitude to science" (p. 22). This claim is still valid, especially for physical science and engineering, as these fields are still perceived as masculine disciplines, in both boys' and girls' views (Farenga and Joyce 1999). In looking for students' perceptions of scientists, most girls and boys draw a scientist as a man (Boylan et al. 1992; Chambers 1983; Finson 2003), especially in middle and high school grades (Fung 2002). Similar results were found for students' perceptions of engineers (Fralick et al. 2006). Hence, for most students, boys and girls, science and engineering, as well as scientists and engineers, all belong to the male domain.

Capability of Dealing with STEM

Since science and engineering are perceived by both girls and boys as male domains, and girls tend to believe they would not be capable of dealing with such subjects (Farenga and Joyce 1999; Jovanovic and King 1998). Girls might believe that women, in general, can pursue a STEM career, but not themselves (Lightbody et al. 1996). The belief in the capability of dealing with STEM and of having necessary skills for STEM is the fundamental need for developing preferences for that profession (Correll 2004).

STEM Career Choice

Students' declarations on future career choices are dependent upon gender identity. There is evidence that more boys than girls are willing to consider studying science and engineering in the future. Even girls, who believe they are capable of dealing with STEM, hold a view of the elimination of possibilities in these areas (Murphy and Whitelegg 2006). Students make their decisions in order to conform to the traditional notions of man and woman, whereby science and technology are considered for boys as a masculine identity, while for girls as a not-feminine identity (Archer et al. 2012; Murphy and Whitelegg 2006; Whitehead 1996).

Role Model and Its Influence on Profession Choice

The BAMOT project is based on the assumption that meeting with feminine role model scientists will foster the girl students to choose STEM careers. This assumption is based on studies that show a positive influence of meeting with scientists, males and females, that can serve as role models for students, both boys and girls (Adedokun et al. 2012; Stoddard 2009). However, research has shown that people tend to choose a profession when they are familiar with a person, or at least are able to identify a role model in that field (Lent et al. 1994; Zirkel 2002). Hence, efforts are invested in finding ways of creating role model scientists in formal as well as informal settings. For instance, Leblebicioglu et al. (2011) studied the positive effect of informal and formal interactions between scientists, males and females, and children, boys and girls, at a science camp on their images of scientists.

Female role models can influence a profession, especially on women in the context of STEM occupation (Betz 1994; Quimby and DeSantis 2006). Therefore, positive images of women scientists and engineers can influence a girl student's commitment to a scientific career (Wyer 2003). A positive effect was accepted by Farland-Smith (2009) who investigated girls' perceptions of scientists after they were mentored by female scientists through the informal settings of a summer camp. Other researchers make suggestions on interventions in formal settings, such as having female scientists as classroom visitors, and through the visits provide opportunities for informal interactions (Finson 2009; Minogue 2010). In contrast, a recent study completed by Betz and Sekaquaptewa (2012) showed that exposing middle school girl students to feminine STEM role models through articles reduced their interest in math, as well as their capability of dealing with math and their future plans for a STEM career.

Some of the interventions mentioned above helped in improving students' perceptions of science and scientists.

However, does it help in fostering students to choose a STEM profession? Rahm (2007) claims that meetings with scientists influence students' perceptions of science as being interesting, but do not change their view of self as pursuing a STEM career. Although students in his research, boys and girls, met with scientist role models (males and females), they still did not believe they were capable of dealing with science and believed that a scientific career was beyond their reach.

The study described here deals with an intervention of women scientist role models that aimed to improve girl students' perceptions of science and to help them see themselves as pursuing a STEM career.

Research Purpose

This study deals with the effect of girls' school visits to a high-tech company and meeting with women scientists, aiming to encourage the participating girls to choose a STEM future career. The following research questions guided the study:

1. What are the girl students' perceptions of women scientists and engineers, their own capability of dealing with STEM, and their tendency to choose a future STEM career?
2. How and to what extent are these perceptions changed following visits in a high-tech company and meeting with women scientists and engineers?

Methods

Settings

The study was conducted in one of the biggest high-tech companies in Israel, which is located in the north of the country. The company provided a special program for girl students from schools in the region. Through the program, the students met with women scientists and engineers of the company at their school, and came for class visits to the company. Twelve female scientists and engineers of the company voluntarily took part in the program; most of them hold a Ph.D. in engineering or science. Since the women in that company were involved in both research and development, the differentiation between scientist and engineer is not clear. Hence, both terms—*scientist* and *engineer*—are used in this paper with no distinction.

Sixty ninth-grade girl students who participated in the program encompassed the research group. The girls came from a Jewish modern-orthodox single-sex secondary school in the same city of the company. The school is known for its high achievements in the national standard matriculation exams. In addition, a control group contained 30 girls from the same classes who did not participate in the program. The grade level was chosen by the company, since usually at the end of ninth grade, the Israeli students choose a major topic in which they will be tested in a national standard test at the end of 12th grade. No selection was made by the school or the company; hence, every student who wanted to take part in the program was allowed. Consequently, all the control group students chose not to take part in the program.

The program included an opening activity at school, two visits in the company, and a summary meeting at school. Through the opening activity, the women scientists introduced themselves and described their work, their educational background, and some personal details, such as where they live and the number of children they have. The girls and their parents listened to the introductory panel, watched a video clip regarding the company products, and could ask the women questions about their work and their personal life. A few weeks following that meeting, the girls came to the company. Two groups of 30 students each had two 4-h visits in the company, guided by the company women scientists and accompanied by school teachers. In all of the visits, the accompanied teachers were not science or math teachers.

Through the visits, they listened to lecture about technologies which have been developed in the company, visited laboratories, observed demonstrations, and could touch materials such as glues and metals. The subjects of the visits of one of the groups were MEMS and chemical reactions, while the subjects of the visits of the other group were space and materials. None of the subjects was connected to the ninth-grade school science curriculum.

Every woman scientist who guided a session in the visits introduced herself, and described her path of choosing a profession. They talked about difficulties and challenges that emerged from being a woman in a masculine setting. The women scientists encouraged non-formal discussions regarding inequitable gender relations, satisfaction, and family-work balance.

A few weeks after the last visit, a summary meeting took place at school. The meeting included a video clip of the girls in the company and a card game in groups that were guided by the company scientists, and will be discussed in detail in the research tools section.

Research Tools and Data Collection

As suggested by other researchers in studying out-of-school experiences (Rennie and McClafferty 1996; Rennie and Williams 2002), a mixed methods approach was

Table 1 Examples of pre-post questionnaire items

Section	Example
Background	Do any of your relatives work in science or engineering? If yes, please indicate the relation
Perceptions of women scientists or engineer	Please describe how, in your opinion, a woman engineer looks
Capability of dealing with STEM	Will you be able to work in the future in a job that deals with science and technology? Why?
Future career choices	Which of the following factors has influence on you when you decide what major to study: your parents, your interest in that topic, the option to have in the future a job you like, the option to have in the future a job that fits mothers who have children, etc.

Table 2 Number of girl students who responded to pre-post questionnaires

Group	Questionnaire	Number
Research	Pre	36
	Post	29
Control	Pre	26
	Post	18

adopted in order to explore the experience the girls have had in the company and its merits.

Observations

Each visit was observed by the author, who took notes focusing on scientific concepts, asking questions, scientist–student and student–student interactions.

Questionnaires

Pre-post open-ended questionnaires were conducted at school. The same questionnaire was conducted before and after the program, both for the research group and the control group. The items of the questionnaire dealt with the students' background, their perceptions of women scientists and engineers, their capability of dealing with STEM in the future, their major topic choice, and future career choices. Table 1 presented examples for items in each section.

For logistic reasons, not all of the students responded to the questionnaires. Table 2 describes the number of students who completed the questionnaires in both times.

Focus Groups

At the summary meeting, focus group interviews were conducted. As mentioned by Osborne and Collins (2001), the female voice is often neglected in a male–female discourse. Therefore, the single-gender discussions enabled exposure to a clear feminine voice. The focus group interviews were centered on a card game that includes three packets of cards which were specially developed for the study. Each packet of cards deals with one of the following topics: students' perceptions of women scientists and engineers, students' capability of dealing with STEM, and students' future career choice. Each card presents a single statement and belongs to one of the three packets. For instance, the card "A woman scientist/engineer is well appreciated by the society" belongs to the packet that deals with perceptions of women scientists and engineers; the card "A woman scientist/engineer deals with complicated things that I will never be able to do" deals with the capability of dealing with STEM; and the card "It is important for me to study toward a job that will enable me to get a high salary in the future" deals with future career choice.

Seven groups of 6–8 students each got one packet of cards that dealt with one of the three topics. Each student had to choose a card with a statement that fits closest to her ideas. After the choice of the card, each student presented her card and explained why she chose that statement. All the group discussions conducted simultaneously in a large open space room during a summary session at school. Hence, the 10 women scientists were divided in order to lead the discussions of the seven groups. Each group discussion was led by 1–2 women scientists of the company, who were trained in leading focus groups. Attention was paid to inter-group interactions, a meaningful factor in a focus group interview (Bader and Rossi 2002; Krueger 1988; Morgan 1996). In addition, the women scientists paid attention for making a comfortable atmosphere encourage the girls sharing honest feelings. In general, the focus group helps interviewers express feelings and thoughts they might not feel comfortable to share in an individual interview (Krueger 1988).

Overall, seven interviews of 50 min each included discussions on two out of the three packets, which were divided between the groups in order to cover all the three topics. The interviews were audiotaped and verbatim transcribed.

Data Analysis

A directed content analysis methodology was used in order to analyze the interviews and the open-ended items of the questionnaires' data. This approach aimed to extend

Table 3 Categories, subcategories, and examples for data analysis

Category and subcategory	Example
Perceptions of women scientists	
Looking	Clean and well groomed
Personal characteristics	Smart, creative, organized, and responsible
Social skills	Can work in a team, has strong social relations
Stereotype elements of scientists (Finson 2003)	Wears glasses
Capability in dealing with STEM	
Positive	Yes, there is no difference between men and women in that issue. There are very smart and very talented women who can work in such a job
Negative	These subjects are too complicated for me.
Questionable	Maybe, I don't know exactly what I'm going to do when I grow up
Future career choice	
Science and technology	It is interesting for me, and the salaries are high
Social and art sciences	I would like to study literature, because it is interesting for me
Deliberate	Physics or art, I'll see
Undecided	I don't know yet

conceptually a theoretical framework that provided predictions about the categories of interest and initial coding scheme (Hsieh and Shannon 2005). The initial categories defined students' as follows:

1. Perceptions of women scientists and engineers—girls' perceptions of women scientists and engineers, in terms of looking, personal characteristics, family and social life. In addition, it includes elements which are well known as stereotypes of scientists, such as glasses, laboratory coat etc. (Finson 2003).
2. Capability of dealing with STEM—girls' beliefs about women's, in general, and themselves', in particular, ability to study STEM as major topics and to pursue a STEM career
3. Future career choice—girls' current tendency of having a STEM career when they grow up.

Table 3 presents examples of the initial categories and the subcategories that emerged from the data.

In order to compare pre- and post-questionnaires, and research and control groups, data were statistically analyzed applying Fisher's exact test that fits the size of the sample. A descriptive–interpretative approach was adopted with data gathered through the observations' field notes.

Table 4 Percent of students who have relatives that work in science and technology

Relative	Research group ($N = 36$)	Control group ($N = 26$)
Father	25.0	23.1
Mother	16.7	15.4
Siblings and grandparents	22.2	19.2
Aunts, uncles, and cousins	19.4	19.2
No relatives	44.4	53.8

Findings

Background: Relatives Who Work in Science and Technology

Based on the questionnaires, data regarding the background of research and control group students were found, in terms of students' relatives who work in science and technology. Table 4 presents the percent of students who had relatives in several family relationship levels who work in science and technology: a father, a mother, siblings, and grandparents; or aunts, uncles, and cousins.

Data show about half the students, both in research and the control group, had no relatives who work in science and technology. About a quarter of the students had a father who worked in science and technology, and about 16 % of students in each group had a mother who had a career in science and technology (one student can have relatives in more than one category). About a fifth of the students had siblings or grandparents, and the same number had other relatives who had jobs in the STEM fields. The similarities between the research and the control groups express no difference between the groups, in terms of accessibility to a relative who works in STEM. Almost the same numbers of students in both groups are very familiar with a person who works in science or technology.

Perceptions of Women Scientists and Engineers

In the questionnaires, students were asked to describe literally how a woman engineer or scientist looks. Some of the descriptions related to her looking: for example, "meticulously dressed" or "unkempt looking." Some of the descriptions included assertions related to her personality: for instance, "smart," "serious," "responsible," and "invest her time in things she likes." Other assertions related to social skills, such as "people listen to her opinion." In addition, some of the descriptions included the scientist stereotype elements that are mentioned by the literature (Chambers 1983; Finson 2003), such as glasses,

Table 5 Students' perceptions of women scientists and engineers (%)

Category	Research group		Control group	
	Pre ($n = 36$)	Post ($n = 29$)	Pre ($n = 26$)	Post ($n = 18$)
Positive relation to looking, personality, and social skills*	52.8	31.0	26.9	50.0
Negative relation to looking, personality, and social skills	2.8	13.8	7.7	11.1
Stereotype elements	27.8	17.2	23.1	5.6

* $p < 0.05$

laboratory coat, and test tubes. Table 5 presents the percent of students who related in a positive way or a negative way to looks, personality, and social skills, as well as stereotypical elements.

A significant decrease was found in the positive view on women scientists and engineers of the research group. At the end of the project, fewer students described a woman scientist in a positive way. This finding was not accepted for the control group.

However, through the interviews, students expressed their respect to women scientists and engineers. Through the card game, the two most frequent chosen cards were "A woman scientist/engineer is smart" and "A woman scientist/engineer thinks out of the box." Here are a few examples for discussions regarding this respect:

Student A: And I saw [through the visits] that you really need to open your mind, to see things not only in one way, but in a few ways.

Student B: Because the inventions, they are things that not every day one says: 'Let's invent it.' You need to think differently.

The second frequent card was "A woman scientist/engineer needs to deal with a masculine environment." That issue appeared in most of the groups and might be caused by the fact that these students study in a single-sex school. Here are two examples:

Student A: There are not so many women engineers, so most of the people you will be with at work, actually, you will be in a masculine environment. Therefore, you will need to deal with it.

Interviewer: What do you mean to deal with?

Student A: To be with men. It is more comfortable to be with women, sometimes.

Student B: In these hard disciplines there are more men than women. It is really interesting for me to know whether she [the woman scientist/engineer] needs to behave differently

Interviewer: What do you think? Will you behave differently if there are more men around?

Student B: Yes, because I will need to prove myself because I'm different.

The third frequent card was "A woman scientist/engineer can combine a scientific career with family life." Some students talked positively about the women scientists they met and their ability to combine family life with a scientific career. For instance, in the interview a student mentioned: "The women engineers we saw succeed in combining family life," and in the questionnaire a student wrote "A mother of children can work there."

On the other hand, some students expressed a skeptic view about the capability to combine a scientific career with family life:

Student: I chose [the card] 'A woman scientist/engineer has no time to spend with her family'. I would have changed the 'no' into 'less'. She has less time because she is at work. She does not pick up her kid from school, she does not cook him food. She does not do it.

Another student shared her own experience with a scientist mother:

Student: I would like to say something. In my family, my mother works in a similar work, and I'm against it, personally, I'm against [the name of the company]. I don't want to work there, and I don't want other women to work there … My mother enjoys her work very much, but me and my siblings do not enjoy it at all. I don't think she succeeds in combining a scientific career with family life … It is not such a fairy tale or perfect, because you enjoy work, but you lose your family.

That issue arose in most of the groups and took a significant amount of time of the discussions. Most of the women scientists had families with children, and hence that issue arose both in the introduction panel, in the informal discussions through the visits and through the focus group interviews. However, it is the place to mention that the importance of that topic for the ninth-grade students might be influenced by cultural factors, which will be discussed in detail in the "Discussion" section of the paper.

Table 6 Students' capability of dealing with STEM (%)

Category	Research group		Control group	
	Pre ($n = 36$)	Post ($n = 29$)	Pre ($n = 26$)	Post ($n = 18$)
Yes, if I want I will succeed	55.6	51.7	42.3	61.1
Maybe	27.8	17.2	15.4	11.1
No, I cannot or I am not interested*	5.6	31.0	38.5	11.1

* $p < 0.05$

Table 7 Percent of students' preferable major topic

Preferable major topic	Research group		Control group	
	Pre ($n = 36$)	Post ($n = 29$)	Pre ($n = 26$)	Post ($n = 18$)
Science and technology*	80.6	58.6	34.6	55.6
Social and art sciences*	5.6	27.6	26.9	44.4
Deliberate between science and technology and social and art sciences	5.6	13.8	15.4	0.0
Not decided or not answered	8.3	0.0	23.1	0.0
Total	100.0	100.0	100.0	100.0

* $p < 0.05$ for research group only

Capability of Dealing with STEM

In the questionnaires, students were asked whether a woman can deal with science and technology. About 90 % of the students, in both research and control groups and in both pre- and post-questionnaires, were sure that a woman can deal with STEM exactly like a man. The other students claimed that a woman's cognitive abilities to deal with science are not different from a man's. But, a woman has constraints related to have family that might prevent her from dealing with STEM. For instance:

Interviewer: Can a woman deal with science and technology?

Student: I think no. Not because she is less smart than a man, but because these jobs require lots of work and lots of hours.

In addition, students were asked about their own capability of dealing with STEM. In response to this question, a significant decrease was found from the pre-questionnaire to the post-questionnaire in the research group data, as presented in Table 6.

About half the students in the research group, both before and after the project, believed they can deal with STEM (55.6 % at pre and 51.7 % at post). This group of girls had no doubt in their abilities to deal with science in the future. These students know that if they want to, they will be able to deal with and to work in such a profession in the future.

In contrast, among the other students who were not sure of their capabilities, a significant decrease was found, where more students claimed they cannot deal with STEM or they are not interested to deal with it. The opposite trend was found for the control group. In that group, significantly fewer students thought they could not deal with STEM in the future in the post-questionnaire.

Even in the interviews, the research group students expressed their doubt in the option of working as a scientist or as an engineer in the future. Here is an example:

Student: [I chose the card] 'A woman scientist/engineer does complicated things that I would never be able to do'. It is hard. It seems hard to me.

Interviewer: Why don't you believe that you too can do complicated things?

Student: Why? Because it is hard. I don't know… I don't have it. I know that I would not be accepted to 5 point physics (equivalent to AP physics program). If I had a brain, I would have been going [to AP physics].

The students expressed not only their hesitation regarding a future scientific career, but also not having the abilities and the skills required for science.

Future Career Choices

The most frequent cards that were selected in that category were: "If I work in the future in a job I like, I will be happy" and "If I do not fulfill my qualifications, I would not fill my mission in my life." The amount of interest in the subject and self-fulfillment are the main factors which influence these students' future career choice.

As mentioned earlier, in the Israeli educational system, at the end of ninth grade, students have to choose their major topic. The topics can be categorized into two main categories: science and technology, and social and art sciences. In the school that participated in this study, the science and technology topics that students can choose as majors are physics, biology, and computer sciences. The social and art sciences topics included literature, art, psychology, and public media.

As described in Table 7, at the beginning of ninth grade, the research group was different from the control group in the percent of students who wanted to study science and technology. About 80 % of the research group students claimed they would like to choose a scientific or technological topic for major studies, while about a third of the control group students expressed the same wish. However, at the end of the year, less research group students actually chose a scientific major topic. This trend was not found for the control group.

Through the interviews, some of the interviewers asked the students about their major topic choice. Out of the 29 students who were asked, about 60 % answered they chose a non-scientific major and only 40 % reported on a STEM major topic. This question might arise only in groups where the interviewers noticed that the students were not in a STEM orientation. This finding is in line with the questionnaires' findings regarding the decrease in the percent of students who would choose science and technology major. An example for a discussion regarding that issue is presented here:

Interviewer: So tell me, when I look on the statements and your perceptions of a woman engineer this is what you said: Someone who is respected, someone that knows to cope with challenges, someone who is smart, that people listen to her opinion, someone who is satisfied that she does really important things. So after all we said about how we perceive a woman engineer, does it give you a desire, I mean, to study?

Student A: I think, but we don't have the abilities.

Student B: You need to be smart. Very very …

Student C: And we don't have the abilities.

Interviewer: Why? Why do you think you don't have the abilities?

Student C: Because we are hardly in four point math (medium level for national standards exams), and we, I don't study physics, and I'm not, I'm not interested in it.

In summary, following the visits and the meetings with the women scientists, some of the girls were "frightened": less students percept a woman scientist/engineer in a positive way, fewer students believe in their abilities to deal with STEM in the future, and less students chose STEM topics as majors. All these trends were not found in the control group.

What Happened? Observations Data

The observations data provide some input that can explain the "fear" of science and technology of some of the students, as a result of participating in the project.

As mentioned earlier, the visits in the company were guided by women scientists, most of whom held a Ph.D. in engineering or science. Throughout the presentations, the tours at the labs and the informal discussions, the women used professional concepts which were unfamiliar to the students: for example, polymeric material, membrane, exothermic reaction, ultrasonic waves, amorphous areas, doping (of materials in semiconductors), radium, aerodynamic, and bending load. These concepts and more were mentioned in high frequency and with no explanation through the visits. In addition, the accompanied teachers did not help in explaining the concepts to the students.

Here is an example of the use of unfamiliar concepts through an informal discussion:

Scientist: Physics is a lot of things: gravity, black holes. I don't know how much more difficult it is from studying a new language. Physics is not only vectors. And math also. Math is not only an integral. The snail shell has the same proportion as the sunflower, the golden ratio.

Through these sentences, the scientist used several terms which are not familiar to an average ninth-grade student: black holes, vectors, integral, and the golden ratio. She wanted to convince the students how interesting physics and math are, but the use of such a lot of unfamiliar concepts in only a few sentences might cause the opposite—feelings of fear and of incapability of dealing with science and technology.

Discussion

The findings of this study put in doubt the assumption of the BAMOT project that meeting with role model women scientists will encourage girl students to pursue a STEM profession. As a result of the visits in the company, the research group girls were "frightened": fewer students perceived a woman scientist or engineer in a positive way; more students believed they cannot deal with STEM; and less students chose a STEM major topic. In contrast, these trends were not seen in the research group.

Following the visits, the girl students expressed appreciation to the women scientists as smart and creative, but their beliefs in their capability of dealing with STEM in the future were reduced. Girls in our study were sure about women's cognitive abilities to deal with STEM, and mentioned no difference in these abilities between women and men. However, at the end of the year, half of them did not choose a STEM major topic. This finding supports the claim of Lightbody et al. (1996) that girls' perception on a STEM career is "We can, I can't." The disparity between beliefs about the general and the self-capability of girls should be further studied in the context of encouraging a STEM career.

The main question that arose out of the findings is what, in this project, caused a negative change in the research group's perceptions of women scientists/engineers, the capability of dealing with STEM, and the STEM career choices? I suggest some possible answers to that question:

Answer A: Cognitive Gap

Through the visits and the meetings, the girls have experienced a cognitive gap between their knowledge and the language the scientists used. The scientists frequently used scientific concepts which were unfamiliar to the students, with no explanation. These concepts were not connected to the students' conceptual scheme, and hence, the challenge was out of their zone of proximal development (Vygotsky 1978). Csikszentmihalyi and Hermanson (1995) emphasize the importance of challenges that can be achieved in the out-of-school settings, in order to make the experience meaningful to the learner. The scientists' use of professional concepts which were unfamiliar to the students caused a distancing. The girls were impressed that the women were very smart and creative, but at the same time felt they were not capable of dealing with that profession in the future.

To solve this, there could be an accompanied science teacher that can bridge the cognitive gap. The out-of-school educational research literature discusses the potential of the accompanied teacher to be the bridging unit between the students and the concepts and the ideas they are exposed to in the out-of-school experience (Tal 2005; Tal and Steiner 2006). The teacher is the only person who knows the conceptual world of the students, on one hand, and understands the scientific concepts which are discussed in the out-of-school learning, on the other hand. Hence, the mediating role of the teacher in the out-of-school experience is tremendously important (Author 2005; Cox-Petersen et al. 2003; Kisiel 2003).

In the visits to the company described in this study, the accompanied teachers did not contribute in mediating the experience. A good mediation can help in reducing the threat and the withdrawal of the students. Through the visits, the teacher could connect the new concepts to the known concepts that were learned at school, and could ask the women scientists to stop and explain unfamiliar concepts. In such a process, the students would have been feeling much more comfortable. In addition, they would have been feeling comfortable that not only they did not understand, but also their class mates and adults such as their teacher. Hence, their self-esteem regarding STEM would not have been damaged.

Answer B: Developmental Gap

In middle school, girls start to question their STEM abilities relative to boys' (Wigfield et al. 1991). However, at that age, girl students usually perceive scientists as "too good" or "too smart" to serve as their role models (Buck et al. 2008). A recent study conducted by Betz and Sekaquaptewa (2012) reveals similar findings. In their research, middle school students were exposed to journal articles about women scientists that included pictures of the scientists and their work place. Following that intervention, the motivation of the girls to study math and science reduced as well as their wish to choose such a profession in the future.

It turns out that the intervention of exposing middle school or ninth-grade girl students to role model women scientists might not fit this age group. This kind of intervention can threaten instead of increase motivation. A possible solution regarding answer B can be reducing the developmental gap between the scientists and the students, for instance, having 12th grade girl students meet with graduated women engineers, as was studied by Hochberg (2009). In her study, Hochberg evaluated the positive impact of 12th grade students with graduate students in a university. Similar intervention in the feminine field needs to be further studied.

Answer C: Long-Term Relationships

Buck et al. (2008) asserted that an adult can serve as a role model when she has a caring relationship with the girls. A role model cannot be created when only observed or presented a few times in the girl's life. However, not every child has a caring relationship with a scientist, and such a relationship cannot be designed.

Farland-Smith (2009) investigated girls' perceptions of scientists who were mentored by female scientists through a few days laboratory and field exercises. The relationship of mentoring helped in improving the girl students' images of women scientists. Similar results were accepted by Leblebicioglu et al. (2011) who studied the positive effect of informal and formal interactions between scientists and children at a 10-day science camp. Hence, a solution to answer C can be designing an intensive and long-term mentoring relationship that provides opportunities for formal, as well as informal interactions between the girls and the scientists.

Lockwood and Kunda (1997) assert that the role models who seem very successful can threaten students rather than motivate them and lead to negative self-esteem in the field of the profession. However, there is some evidence that long-term exposure to engineers in the classroom seems to improve students' perceptions of engineering (Fralick et al. 2006). Therefore, long-term relationships with the same women scientists that include formal, as well as informal interactions, discussions about difficulties, failure, and challenges can help the girls see the person behind the success.

Answer D: Cultural Context

The girls participating in the current study came from a modern-orthodox single-sex secondary school. Although there is a debate regarding the influence of single-sex schooling on achievements, there is evidence "these organizations alone do not enhance girls' interest in or motivation to study physics" (Murphy and Whitelegg 2006, p. 29).

The single-sex schooling might influence the girls' reference to the need of a woman scientist/engineer to work in a masculine environment. As mentioned earlier, this was the second frequent card that was chosen to relate to perceptions of a woman scientist and that issue appeared in most of the group discussions. This issue might be a challenge for some of the girls who declared feeling more comfortable only with women than also with men.

Another cultural aspect that emerged from the religious context of the modern-orthodox community is the issue of combining a scientific career with family life. As mentioned earlier, some students talked positively about the women scientists they met and their ability to combine family life with a scientific career. On the other hand, some students expressed a skeptical view about the capability to combine a scientific career with family life. "Family" is a main value in the Jewish orthodoxy, and hence, that issue arose in most of the groups and took a significant amount of time in the discussions. In general, the average number of children per woman in Israel in 2011 was 2.98, while in the OECD countries, the average is 1.7 (The Israel Central Bureau of Statistics 2013b). For orthodox, as well as modern-orthodox, religious women, the average is even higher (The Israel Central Bureau of Statistics 2011). Therefore, the girls in this study expressed concerns regarding demanding scientific career even when they were only 15 years old.

A solution to answer D can be a role model of the same cultural group, as suggested by Bandura (1977, 1986). In this study, two out of the 12 women scientists were modern-orthodox. Long-term relationships with similar cultural role models might help the students connect their image of scientists to their future self (Packard and Wong 1999).

Unexpected results were accepted from the control group. Although that group did not receive the intervention, yet their pre- and post-questionnaires results significantly changed in their positive perceptions of women scientists. In addition, from pre to post, fewer students in that group believed they could not deal with STEM. These unexpected findings could be explained by the interaction between the two groups—research and control. It can be assumed that when the research group students returned to school, they shared positive experiences with their peers who did not come to the visits. This might affect positively on the attitudes of the control group students.

Limitations and Further Study

This study is limited by the students' self-selection to participate in the program that might be influenced by their initial attitudes toward science. In addition, during the visits, the research group students interacted mostly with women role models and not with men. The research is also limited by the possible interaction between the research and the control groups.

This study highlights the need for research and development of effective interventions of women role models in order to encourage girls to pursue a STEM career. It also reflects the need for investigating additional social projects by the industry, in order to path the resources invested in these projects into an effective contribution.

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