

Factors Influencing the Shrinking Pipeline in High Schools: A Sector-Based Analysis of the Israeli High School System

Larisa Eidelman and Orit Hazzan
Department of Education in Technology & Science
Technion - Israel Institute of Technology
Haifa, Israel 32000
<elarisa , oritha @ techunix.technion.ac.il>

ABSTRACT

The study described in this article continues research on gender-related issues in Computer Science education by focusing on the differences between two sectors in the Israeli high school system – the Jewish sector (majority) and the Arab sector (minority). As it turns out, the under-representation of female high school students in CS studies is significantly more salient in the majority sector. This study explores this situation and attempts to explain it. We also explain how the findings of this research can be applied to other countries and societies.

Categories and Subject Descriptors

K.3.2 [Computers and Education]: Computers and Information Science Education – *CS education*.

General Terms

Human Factors.

Keywords

Computer science education, high school, gender, culture, Israel.

1. INTRODUCTION

Worldwide surveys indicate that the number of women studying undergraduate-level Computer Science (CS) is constantly decreasing [3]. According to Galpin [5], the low participation of women in the computing studies is recognized worldwide. As it turns out, the situation is similar among high school students as well. However, while many studies are carried out at the university level and programs are implemented in order to change the situation, high school students do not attract such attention. In Israel too, as far as we know, no research has ever been performed that focused on female high school students studying CS. This article presents such a study. Specifically, it focuses on high school students studying advanced-level CS.

Based on data collected in Israel, significant differences were found in the percentages of female high school students studying advanced-level CS among different sectors. More specifically, while the percentage of female high school students studying advanced-level CS is about 50% for the Arab *minority* sector, the percentage of female students studying CS at the same level among the Jewish *majority* sector is only about 25%.

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Different studies around the world identified various factors that discourage women from studying CS and from persisting in the field. By focusing on the Israeli high school female students studying CS at the highest level, we suggest that the research presented in this article may partially explain the above-mentioned phenomenon.

2. RESEARCH BACKGROUND

Margolis and Fisher [7] suggest that the under-representation of women in computing fields is important on two levels: On the personal level and on the societal-cultural level. Therefore, they suggest that the significant differences between the representation of women and men in the CS fields in general, and in high school CS classes in particular, should not be ignored. This under-representation has a special significance in Israel, a small country in which the efficient utilization of its human resources is of great importance.

2.1 Under-Representation of Women in the Computing Fields – A Worldwide Perspective

As mentioned in the introduction, the under-representation of women in the computing fields is recognized worldwide [5]. However, recent in-depth analysis of this phenomenon reveals that the problem is not universal, but rather is restricted to specific countries and cultures [1, 5, 6]. More specifically, in certain countries and cultures, such as Greece, Turkey, Mauritius, and Romanic countries (e.g. France and Italy), the representation of women in CS is relatively high and constant, in contrast to the US, Anglo-Saxon countries, Scandinavian and German-speaking countries, in which the representation of women in CS is relatively low and decreasing. Accordingly, it is reasonable to assume that cultural factors play an important role in encouraging or discouraging women from studying CS.

2.2 Under-Representation of Women in the Computing Fields – An Israeli Perspective

The Israeli high school CS syllabus includes the core of the discipline and is considered to be relatively advanced in comparison to the CS syllabi of other countries. The syllabus is modular and thus enables the study of CS on different levels, ranging from the basic level to a more advanced one. Most of the advanced-level students take the CS matriculation exams at the end of 12th grade, after having taken (and successfully passed) the lower-level exam at the end of 11th or 10th grade. In most cases, advanced-level CS students are required by the school to study advanced-level mathematics in parallel to their CS studies.

Most Jewish and Arab students attend separate educational systems with similar curricula in most subjects. The CS syllabus

is identical in both systems and the only differences are in the teaching language and the language of the matriculation exam.

High school is a critical point in the CS pipeline, at which many female students are lost, mainly in the Jewish sector. As mentioned previously, a significant difference exists in the percentages of female high school students studying advanced-level CS between the Arab and Jewish sectors. Specifically, while 50% of those studying high school CS in the Arab *minority* sector are female students, only 25% of those studying the same level of high school CS in the Jewish *majority* sector are female students. This situation prompted us to initiate this research, which examines the factors that influence the enrollment and persistence of Israeli high school students in advanced-level CS studies. In addition to gender difference research, the co-existence of two populations (Arab and Jewish) in Israel provides an opportunity to examine cultural differences as well.

There is, in fact, another advantage of conducting such research in Israel. One solution that has been suggested for countries in which women are under-represented in CS (and which would like to change this situation) is to visit countries in which this problem does not exist, and to identify the cultural differences, as well as actions taken to encourage women to study CS, which may explain why women in such countries find CS an attractive field. From this point of view, Israel is a perfect place for such research. Specifically, in order to understand the low participation of Jewish female high school students in CS, there is no need to visit another country. It is sufficient to investigate the differences that exist between the two populations that live in the same country and study according to the same curriculum, one of which (the majority) suffers from this under-representation, while the other population (the minority) does not.

The research described in this paper takes advantage of this situation. The specific research questions were:

- What considerations are involved in the decision of Jewish and Arab high school female students to study advanced-level CS?
- What considerations influence the persistence in such studies in each sector?

3. RESEARCH METHOD

The research examined both gender and cultural differences among Israeli high school students studying advanced-level CS. Three comparisons were conducted, as follows: Jewish female students vs. Jewish male students, Arab female students vs. Arab male students and Jewish female students vs. Arab female students. This paper focuses on the differences between Jewish and Arab female students.

3.1 Research Population

The research population consisted of 12th grade CS students from 9 typical high schools, from both sectors (5 schools from the Jewish sector, 4 schools from Arab sector). The schools were selected based on the agreement and permission given by their principals and the willingness of the CS teachers in those schools to let their classes participate in the research.

146 students participated in the research. Table 1 describes the distribution of the students according to gender and sector.

Table 1. Distribution of research population

	Total	Male	Female
Number of students from the Jewish sector	90	(72%) 65	(28%) 25
Number of students from the Arab sector	56	(39%) 22	(61%) 34
Total	146		

The CS teachers and school counselors were included in the research population as well.

3.2 Research Tools

The research applied both quantitative and qualitative approaches. Data were gathered using the following research tools: comprehensive questionnaires completed by all students, ethnographic interviews with female students, and classroom observations during CS lessons. In addition, interviews were conducted with CS teachers and school counselors.

Questionnaires: The comprehensive questionnaire included mostly closed questions in addition to several open questions. The questionnaire addressed the following topics: personal and demographic information; ICT usage; areas of interest in higher education; attitudes towards CS studies; perceptions of CS; stereotypes related to CS; support and encouragement resources; factors that may influence the decision to study CS; attitudes towards the under-representation of women; and considerations in choosing a high school major. The questionnaire was administered to all students in the selected CS classes.

The data collected in the questionnaires were coded and analyzed using the statistical application SPSS. Closed questions were analyzed using statistical tests such as the Kruskal-Wallis test, Mann-Whitney test and logistic regression; open questions were analyzed using content analysis techniques.

Interviews: Ethnographic interviews with 18 Jewish and Arab female students were semi-structured interviews lasting between 45 to 90 minutes. All interviews were transcribed and analyzed using content analysis techniques.

Observations: Observations were made during CS lessons in different schools and classrooms, both during lab lessons and traditional classroom lessons. The manuscripts of the observations were also transcribed and analyzed.

4. PRELIMINARY RESULTS

This section presents data from the questionnaires and the interviews related to three topics: support and encouragement, future and success orientation, and the perception of CS. These data will be discussed in Section 5.

4.1 Support and Encouragement

Several questions in the questionnaire addressed the issue of the support and encouragement to study CS that students receive from different sources. One of the direct questions was: "Who encouraged you to choose CS studies?" Figure 1 presents the distribution of answers to this question.

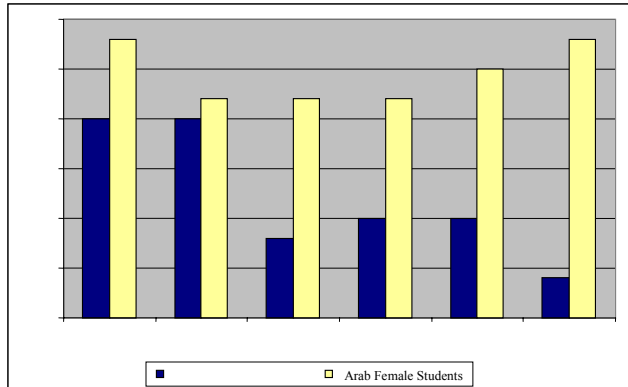


Figure 1. Percentages of females' encouragement by others

Figure 1 reflects an unequivocal conclusion: Arab female high school students ($n=34$) receive much more encouragement to choose CS than do their Jewish counterparts ($n=25$). Specifically, Arab female high school students are encouraged more by their mothers (56% vs. 40%), fathers (44% vs. 40%), siblings (44% vs. 16%), friends (44% vs. 20%), acquaintances who had studied CS (50% vs. 20%) and – with the greatest difference – by their teachers (56% vs. 8%).

In another part of the questionnaire, the students were asked to rate their agreement with the following statement: "Our school encourages its students to study advanced-level CS". The difference between the two populations was significant ($p=0.000$): 91% of the Arab female high school students agreed with the statement compared to only 28% of the Jewish female high school students.

Additional evidence can be found in students' answers to the question in which students were asked to rate the influence of different factors on their choice to study advanced-level CS. Significant differences were found in the influence of the following 4 factors:

a. "Supporting and helpful CS teachers": On a 1-3 scale, the Arab female high school students gave an average rank of 2.4, while the average rank given by Jewish female high school students was 1.2 ($p=0.000$).

b. "School recommendation (teacher, counselor, principal)": Arab female students gave an average rank of 2.0 vs. 1.2 by Jewish female students ($p=0.000$).

c. "Family recommendation (parents, siblings, uncles/aunts)": Arab female students gave an average rank of 2.3 vs. 1.9 by Jewish female students ($p=0.024$).

d. "Friends' recommendation": Arab female students gave an average rank of 2.3 vs. an average ranking of 1.4 by the Jewish female students ($p=0.000$).

In their answer to one of the questionnaire's open questions, Jewish students explained: "Parents don't encourage the girls enough to begin studying CS and since the female students are influenced by their female friends' attitudes towards computing, they don't turn to CS studies (and not because of a lack of required capabilities, since they do have them)" or "There is not enough encouragement for girls! They are afraid CS is a difficult and complicated subject!!! Similar to advanced-level

mathematics, where we are a lot of girls, the same can be true for CS as well!!!!!!".

The difference in the participation of female high school students in CS studies between the two sectors is reflected not only in the number of female students attracted to study this subject, but also in the number of female students that persist in their CS studies. As it turns out, Jewish female students are more likely, compared to their Arab counterparts, to abandon their CS studies during the high school years (especially at the beginning of 12th grade, when the material becomes more complicated).

In the interviews, the female students were asked about their own and their friends' persistence in CS studies. Here is an example of an Arab female student's attitude to this issue, which highlights the importance of the support the female Arab students receive from their environment: "It depends if someone encourages them at all. Look, there are many girls who think that they ought to be satisfied by little, by staying at home and helping out. There are girls who want to be the ideal woman, to study and to do things and get the equality we need, so they fight... Girls need more encouragement than boys, because we (the Arab girls) have a lot of burden and responsibility, more than the boys have." When encouraged by the interviewer to elaborate, "In what sense?" she explained: "In all aspects, at home and in the society, since we are criticized more. And if ... she doesn't have the strength to struggle with the criticism and the studies, it is difficult for her, so she needs someone to encourage her more."

4.2 Future and Success Orientation

Another question that appeared in the questionnaire asked the students to grade the influence of future- and success-oriented factors on their decision to study advanced-level CS. Significant differences ($p=0.036$) were found in respect to several statements: The average rating (on a 1-3 scale) by Arab female students of the statement "A matriculation certificate with CS will help me find a job", was 2.3 compared to 1.8 among their Jewish counterparts. The average rating by Arab female students of the statement "CS is an essential subject for academic studies" was 2.5 vs. an average grade of 1.9 given by Jewish female students ($p=0.001$).

In the questionnaire, the female students were asked about the field they plan to major in, in their academic studies. 45.5% of the Jewish female students were still undecided as to what they would like to major in at the university, as opposed to 9.1% of the Arab female students. 31.8% of the Jewish female students intended to major in a CS related subject, as opposed to 21.2% of Arab female students. 22.7% of the Jewish female students indicated subjects that are unrelated to CS vs. 69.7% of the Arab female students. Figure 2 illustrates these findings.

When asked about gender-related considerations involved in the choice of majors, some of the female Arab students stressed their duties as wives and mothers: "The boys consider how to earn a living, but the girls consider both how to earn a living and be at home"; "A girl, when she decides what subject to study, thinks first about all the time she will need in order to take care of the children she will have in the future, and only then does she think about what subject to study. The boys first think directly about themselves".

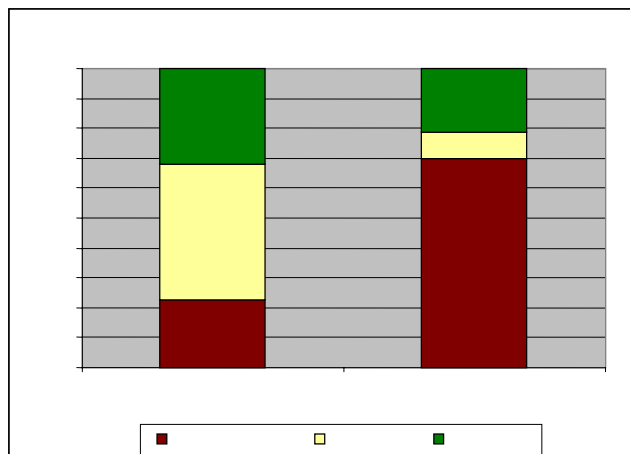


Figure 2. Intended academic studies major

At the same time, however, at the high school level, female Arab students conceive of CS as a way to increase their self-esteem. During her interview, one Arab female student was asked: *"Is it possible that Arab female students find studying CS to be a way to increase the chances of finding a job and achieving economic independence?"* The answer was: *"Yes, sure. CS is like I have a job. People will regard me as...if I have a higher status. They will see a girl with intellect, not just a simple girl. There is a different perspective on a girl who is studying CS. There is more appreciation...When my parents tell their friends that I'm studying CS it gives them more pride and appreciation."*

4.3. Attitudes towards CS Studies

A difference in the female students' perspectives was observed also with respect to their conception of the field of CS. As can be seen in Table 2, the female students from the two sectors view CS in a significantly different way. Only 32% of the Jewish female students who are already studying CS think that CS is important. A higher percentage of Arab female students think that CS is difficult and frightening, but yet a much higher percentage of Arab female students like and enjoy CS.

Table 2. Attitudes towards CS among Jewish and Arab female students

Attitude toward CS	Jewish female students	Arab female students	Difference
Interesting	68%	85%	**
Difficult	16%	35%	**
Essential	56%	38%	**
Boring	16%	9%	*
Enjoyable	28%	53%	**
Frightening	8%	21%	**
Important	32%	77%	**
Liked	8%	50%	**
Surprising	0%	47%	**

**p<0.01, *p<0.05

In addition, one of the questions in the questionnaire asked students to rate factors that relate to attitudes towards CS studies, according to their influence on their decision to study advanced-level CS. Significant differences were found in the average rankings (on a 1-3 scale) by Arab female students and Jewish female students with respect to the following statements: *"CS is a prestigious subject"* – 2.4 by Arab female students vs. 2.0 by

Jewish female students (p=0.049), *"I conceive of CS studies as a challenge for success"* – 2.4 by Arab female students vs. 1.9 by Jewish female students (p=0.035) and *"I enjoy studying CS"* – 2.4 by Arab female students vs. 2.1 by Jewish female students (p=0.032). When asked about their agreement with the statement *"Studying advanced-level CS is a challenge"*, 82% of Arab female students agreed with this statement as opposed to only 36% of the Jewish female students.

5. DISCUSSION

In the discussion we will explain and discuss the findings presented in the previous sections.

5.1 Subject Diversity: Is it Good or Bad?

Currently, the Jewish and Arab sectors in Israel study in separate educational systems. As mentioned previously, both educational systems have a similar structure in terms of the basic curriculum. In what follows, we explain the above findings through some of the structural differences that do, nevertheless, exist between the two educational systems.

High school students can choose to specialize (advanced-level studies) in specific subjects taken from two groups: Group A includes the traditional scientific fields: mathematics, physics, chemistry and biology; and Group B includes CS, economy, communication, psychology, sociology, languages, law, art, drama, music, tourism and theater. As it turns out, the most prominent difference between the two educational systems is in the diversity of the subjects offered at an advanced level. Both systems offer the same variety of Group A subjects; however, while most Jewish schools offer a variety of Group B subjects, most Arab schools offer very few subjects from Group B. As a result, when 10th grade students are required to choose specialization subjects for their high school years, Jewish students have many options to choose from in Group B compared to Arab students who have less choice. Specifically, Jewish female students have the option of choosing traditional "feminine" subjects (like psychology) while Arab female students are, in most cases, restricted to a choice of more "masculine" subjects (such as CS). Moreover, most of the other Group B subjects are considered by students to be easier and to require less effort compared to CS. Thus, for Jewish female students the alternatives seem much more attractive.

This situation is reflected clearly in the interviews, in which the female students were asked: *"Which subjects did you have doubts about when you had to choose your majors?"* A typical answer given by a Jewish female student was: *"I didn't choose physics, because I didn't really see myself there ... I didn't feel the connection in any way. And versus chemistry I had drama, so I preferred drama, because I felt a connection. Later I changed drama to social sciences and instead of physics I took CS"*. Such answers clarify the idea that because of the alternatives that exist in the Jewish schools, the choice of CS is not trivial or obvious. A typical answer of an Arab female student was: *"There were biology, physics, chemistry and CS. I had doubts between CS and physics"*. Arab female students were then asked what their choice would have been had their school offered more Group B subjects, such as art. Following is an answer given by one of the Arab female student: *"Yes. First of all it's easier and it explains why there are more boys than girls (in the Jewish sector), because boys won't take drama, theater or art though they will take CS. It*

suits them more. But the girls think it's easier, so why not. It suits the girl's personality".

Ultimately, we see that the limited option in the Arab sector actually benefits Arab female students and exposes them to prestigious areas, such as CS. At the same time, the existing diversity offered in Jewish high schools, while aiming to enable all students to study subjects according to their capabilities and areas of interest, draws female students away from CS. *Well, subject diversity - is it good or bad?*

5.2 High School Female Students As a Minority or Majority: What Can Be Gained?

In this section, we analyze the situation described in this article by examining the unique characteristics of the Arab-Israeli society that are likely to influence Arab female students to choose and persist in CS studies. Furthermore, we ask what can be learned and adopted from such findings, by the Jewish-Israeli society in particular, and by other countries dealing with a similar high school female student minority in CS in general.

As shown in Section 4.1, noticeable differences exist in the extent of encouragement Arab female students receive from various agents, especially from teachers, in comparison to Jewish female students. Even in light of the renowned, greater appreciation and respect given to teachers in the Arab sector, the differences, we suggest, are still enormous. One possible explanation for such an extent of encouragement is based on findings of other studies that explored cultural and familial differences between Arab and Jewish adolescents. According to these studies, since Arab students are part of an Eastern, collective culture, as well as a minority group, it is likely that they are "pushed" by their parents to higher scholastic achievement in order to improve their social status [8].

In addition, Arab students perceive their family environment as more authoritarian than do their Jewish counterparts. The hierarchical structure of the Arab family is based on age, and traditionally requires the young to obey the old and adhere to their expectations [8]. Furthermore, it was found that peer influence in the Arab sector is much more positive than it is in the Jewish sector, possibly because of the relative independence from family and friends that exists in the Jewish sector [2]. This might explain the lower influence of parents and peers in the Jewish sector.

Despite the fact that Arab female students are about half in CS classrooms in high schools, according to their future orientations (Section 4.2), this will probably not help to expand the "shrinking pipeline" in Arab sector. Most of the female students have already decided on their future professions and only a small percent of female Arab students are considering majoring in CS. Thus, the better starting point might not carry over to higher education and industry.

The picture painted by the results of our study is that Arab female students perceive CS studies as a way to provide themselves with increased professional opportunities and especially social status (Section 4.3). This assumption is

reinforced by results of general research focusing on the future orientation of Arab adolescents, which concluded that Israeli-Arabs perceive high school education as a crucial element in the opening up of employment opportunities and in achieving a higher economic status [2]. In order not to be inferior in the eyes of their family in particular and society in general, it seems that Arab female students are highly motivated to study CS since they consider these studies as a way in which to prove their skills and capabilities. They also hold relatively positive attitudes toward CS compared to Jewish female students (Section 4.3). Since it was found that positive attitudes of the female students towards computing influenced their continued enrollment in computer courses [4], the attraction and retaining levels of CS studying among the Arab female students is clear.

Different social and cultural characteristics stimulate the extensive encouragement the Arab female students receive. Naturally, we can conclude that encouragement may be one solution for attracting female students to study CS and keep them there. By creating an atmosphere that supports the development of positive attitudes towards CS, we can probably attract more female students to study advanced levels of CS.

6. ACKNOWLEDGMENTS

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