

# **FACTORS MOTIVATING THE CHOICE OF MATHEMATICS AS A CAREER AMONG MEXICAN FEMALE STUDENTS**

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*In this paper we present a report of an ongoing research focused on identifying the factors that motivated Mexican female students to choose mathematics as a career. The main body of data for the research was generated through semi-structured interviews. The preliminary results show that three are the main factors that motivated women in the sample to choose mathematics as a career: (1) to be aware of the fact that they are good at mathematics, (2) the influence of their mathematics teachers, and (3) the influence of their relatives. We suggest that these three factors promote the constitution of a mathematical identity, which in turn favors the choice of mathematics as a career.*

## **INTRODUCTION**

There are several reports indicating that few tertiary students around the world are enrolled in science, technology, engineering and mathematics (STEM) related careers (European Commission, 2004, Organisation for Economic Co-operation and Development, 2008; Stine & Matthews 2009). In particular, the recruitment rate of women in these areas is particularly low (see for example European Commission, 2009). Meeting the demand for scientists and engineers is a widespread concern because of the important role that these careers play in the development of modern society; however, there is also a global interest in producing a diverse and gender balanced scientific workforce. This situation has generated a number of studies that try to identify what factors attract and retain students (particularly women) to STEM careers (see for example Brickhouse, Lowery & Schultz, 2000; Herzig, 2004; Hill & Rogers, 2012; Mendick, 2005).

The situation in Mexico, where this study is being developed, is not different from that described above. The recruitment rate of female students in STEM careers, particularly in mathematics, is very low. The latest figures on the study of mathematics at the tertiary level in Mexico show that: (1) women represent 38% of the people studying a bachelor degree in mathematics; (2) women represent 24% of the people studying a master degree in mathematics; and (3) women also represent 24% of the people studying a PhD degree in mathematics (data taken from Barrera, 2012).

In spite of these problems to attract women to the study of mathematics, there are very few studies in Mexico (and in general in Latin America) focused on identifying the factors that may attract and retain female students to study math-related careers in this region. The latest Mexican study focused on this issue is that of Jiménez (2006), where some female researchers in mathematics were interviewed about the reasons that led them to choose mathematics as a field of work.

In this paper we report an ongoing research project focused on identifying some of the factors that may motivate Mexican female students to choose mathematics as a career. Specifically, we are trying to answer the following research question:

*What factors motivates Mexican female students to choose mathematics as a career?*

The main contribution of our work is to help to understand what motivates female students from Latin American countries to choose mathematics as a field of study. Our research could help to identify differences and similarities between the motivating factors to study mathematics among women from different regions of the world. We also believe that our research can produce pedagogical recommendations to promote the study of mathematics among young women in our country.

The manuscript is organized as follows: first, we will summarize the literature that we have consulted so far and clarify what is the function that this literature review has had in our research; then, we will explain the approach we have taken to collect and analyze empirical data; next, some preliminary results are presented, this is, some of the factors that seems to motivate Mexican female students to choose mathematics as a career; then, we will refer to the concepts of self and identity as theoretical tools to try to interconnect and make sense of the results obtained; finally we will present some conclusions.

## **A REVIEW OF RELEVANT LITERATURE AND ITS ROLE IN THE RESEARCH**

When we began our review of the literature, we focus initially on mathematics education research journals, trying to locate studies that could explain why few women choose to study mathematics. In a second stage we extended our search to science education journals, trying to locate articles focused on studying what factors attract and retain female students to STEM careers.

The literature review had a dual role in our research. On the one hand, it allowed us to locate some of the methods used in the literature to identify the factors that may motivate women to study STEM careers; we used this information to design our own research method. On the other hand, the literature review was useful to identify hypotheses or possible explanations on why some women are attracted to this type of careers.

Regarding the methods used, we found that in some studies questionnaires are employed in conjunction with other instruments (for example in Holmegaard,

Ulriksen & Madsen, 2012; Sjaastad, 2012), but most studies use open interviews to allow women to produce narratives about their experiences with mathematics (see for example Mendick, 2005; Piatek-Jimenez, 2008; Solomon, 2012). Through these personal narratives researchers try to locate activities and experiences that have led women to study mathematics.

With regard to the hypotheses or possible explanations for why some women choose to study (or not so study) mathematics-related careers, they are very different in nature. To explain why some women choose not to study mathematics, some authors claim that mathematics can be perceived as an unfeminine profession, resulting in a discrepancy between female identity and a mathematical identity (Piatek-Jimenez, 2008; Solomon, 2012). Another explanation for the low number of women in mathematics as a field of study is that there is discrimination against women in math-intensive fields and in the mathematics classroom —sometimes unconsciously— (Ceci, Williams & Barnett, 2009). There are authors who claim that the level of creativity required in some hard sciences, which is not socially favored among women, can be a reason why there is a low presence of women in these sciences (Hill & Rogers, 2012). There are at least two factors that have been identified as motivating and inspiring for women to study mathematics-related careers: (1) the confidence that individuals have in their own intellectual abilities (Eccles, 2007) and (2) the positive influence of significant persons, such as parents, teachers and friends (Sjaastad, 2012).

During our review of the literature, we also noted that some studies associate the process of choosing a career with the construction of an *identity* in young people. For example, Sjaastad (2012) uses as a theoretical tool the concept of *self*; he bases his discussion of the concept of self in the works of Higgins (1987) and Swann & Bosson (2010). The self refers to the attributes that a person believes to possess and the attributes the person would like to possess. One important thing here is that, the self is influenced and shaped by interpersonal relationships; as stated by Swann & Bosson (2010): “We know ourselves [...] by observing how we fit into the fabric of social relationships and how others react to us” (p. 589).

In turn, Holmegaard, Ulriksen & Madsen (2012) relate the choice of a career with the process of defining oneself:

“[T]he decision about which course of study to choose after finishing upper-secondary school is not limited to figuring out what could be interesting or promising; it is also about *defining* oneself, and making a decision about whom one wishes to become” (p. 4).

Similar to the theoretical position of Sjaastad (2012), Holmegaard, Ulriksen & Madsen (2012) conceptualize the constitution of an identity as shaped by interactions with others and the cultural context where the person is immersed.

The concept of *mathematical identity* or *identity as mathematics learner* can also be found in the literature on mathematics education (see for example Anderson, 2007;

O'Hara, 2010). The construct of identity refers to “the way we define ourselves and how others define us” (Anderson, 2007, p. 8), and serves to explain what makes a person to feel like an able mathematics student and as a consequence get involved and engaged in mathematical activities. As we shall see, this construct could be helpful to explain some of the results of our study.

## **METHOD**

After identifying in the literature some of the factors that motivate women to pursue a career related to mathematics, we conducted an exploratory study. A role of this exploratory study was to verify whether the factors located in the literature appeared in Mexican female students; another role was to try to identify other possible motivating factors not reported in the literature.

### **Description of the exploratory study**

For the exploratory study a questionnaire was applied to 32 Mexican girls studying a bachelor degree in mathematics in the University of Veracruz, located in southeast Mexico. The questionnaire was applied during February 2012. The head of the mathematics department administered the questionnaire to randomly selected students. The selected students had different degrees of advance in their studies, and their ages ranged from 18 to 21. The questionnaire consisted of eleven open questions focused on their experiences with mathematics before entering the bachelor program and their reasons why they decided to study mathematics. It included questions like: what motivated you to choose this career? and, at what point in your life you decided to study mathematics and why? These two open questions were particularly helpful in identifying some of the reasons why these students chose to study mathematics. Among the reasons they expressed in the questionnaire are:

- Their mathematics teachers motivated them to study mathematics.
- Their parents influenced their career choice.
- Participation in competitions like math Olympiads motivated them to study mathematics.
- At some point in their lives they realized that they were good at mathematics and decided to study it.
- At some point in their lives they discovered some sort of mathematical applications and as a consequence they found the study of mathematics appealing.

With these explanations in mind, we designed an interview guide for semi-structured interviews. Through semi-structured interviews we generated the main body of data for the research. Next we explain in more detail how these data were produced.

## **Collecting data through semi-structured interviews**

In this second stage of our study we interviewed 37 female students enrolled in the Higher School of Physics and Mathematics at the National Polytechnic Institute of Mexico, in Mexico City. As in the exploratory study, the selected students had different degrees of advance in their studies, but in this case their ages ranged from 18 to 22. All the authors of this paper participated in conducting the interviews. The interviews took place between August and September 2012, about a month after starting the school year. The student participation was voluntary and the interviews were conducted during downtime between lessons, in the gardens of the Institute. Our purpose was to create a casual and comfortable environment for the students. The interviews were audio recorded and their average length was 12 minutes.

The semi-structured interview guide contained a couple of open questions aimed at triggering students' narratives on the activities and experiences that motivated them to study mathematics. These open questions were: (1) can you name one or more experiences or activities of your past that influenced you to choose this career? and (2) was it difficult to choose your career, did you always know you wanted to study this or was there any particular incident that made you choose this career?

There are several similarities between the two samples we used in this study. On the one hand, both samples consist of Mexican women who are studying a bachelor degree in mathematics in a public school, this means that their socio-economic backgrounds should be similar (most likely belonging to middle class or lower middle class); another similarity is their age ranging from 18 to 22; also, both groups of students are studying in urban areas, although the students from Mexico City belong to a much more developed urban area. These similarities between samples made us consider that the explanations obtained in the exploratory study could be similar to the explanations provided by the second group of students. Thus, we expected that the above-mentioned questions could elicit narratives in which teachers, parents, or mathematical competitions were mentioned as factors influencing their choice. For this reason we prepared additional questions to deepen each of these factors, in case they appeared. For example: What did you like about your math teacher and her teaching?; How would you describe your experience in the mathematical competition (positive or negative) and why?; How your parents and friends reacted when you told them you wanted to study mathematics?

## **Data analysis**

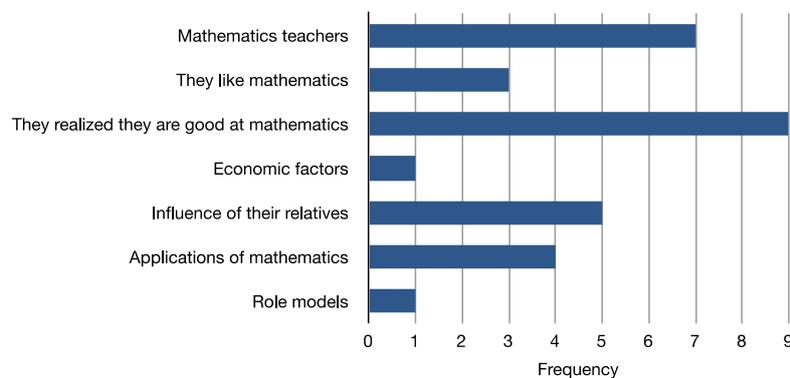
To analyze the interviews the audio recordings were distributed among all members of the research team. When analyzing the audio-recorded interviews, we focused on locating the instances where students mentioned any experience or activity that motivated them to study mathematics. Each of those instances was transcribed. To increase the reliability of the results, two researchers independently analyzed each recording; if there was any discrepancy in the interpretation of the interview, both

researchers explicitly discussed how they were interpreting the content of the interview to reach consensus.

At the time of writing this report we had analyzed 10 out of 37 interviews. The results presented below are based on the analysis of those ten interviews.

## PRELIMINARY RESULTS

The results presented next are the factors that ten Mexican female students mentioned in their narratives as motivating to study mathematics. Some students mentioned more than one motivating factor during the interview. We have classified these factors into seven categories. Figure 1 shows the frequency for each of those categories.



**Figure 1: Some factors that motivate the female students in our sample to study mathematics.**

Now we will explain in more detail each of the categories listed in figure 1:

*Mathematics teachers.* Mathematics teachers are the second most mentioned motivating factor among the students. There are several aspects that students highlight about their teachers: Some mentioned that they liked the way they taught, for example, by presenting step by step and detailed explanations of the topics; others mentioned that their teachers were enthusiastic and they transmit them their love for mathematics; other students, as illustrated in the following transcript, mentioned that their teachers assigned them extra activities and even invited them to some math-related extracurricular activities (like math competitions):

Student: The teacher taught me many things because I was interested; then, after finishing the class, she gave me more lessons, she taught me more things. Actually I went with her to several competitions

*They like mathematics.* When asked what motivated them to study mathematics, some students simply respond: “because I like them”. When asked why they like mathematics, one student said that she liked mathematics because of its exact nature, and because of the pleasure felt when solving a problem. However, some students find it difficult to clarify their reasons:

Interviewer: Can you explain why do you like mathematics?

Student 1: Well, not really. It's a delight, as someone who loves music.

Interviewer: Why do you like mathematics?

Student 2: I have no exact idea... I like them because... I don't know how to say it, I feel like it is a science.

*They realized that they are good at mathematics.* The main motivating factor mentioned by the students was that, at some point in their life, they realized that they were good at math. Different situations allowed them to recognize their mathematical skills: In some cases their teachers explicitly told them that they were good at math; some students noticed their mathematical skills because they did well in mathematical competitions or because they got good grades; some received social recognition when their classmates asked them for help to study or to solve their homework. In some cases there was also a self-recognition of their mathematical skills when noticing that their peers struggled to solve mathematical tasks while they solve them with ease.

*Economic factors.* There was a student who said that she would have liked to study a bachelor of finance at a private university, but due to financial constraints, she had to choose another math-related career at a public university. It was then when she decided to study a bachelor degree in mathematics.

*Influence of their relatives.* The family is an important source of motivation for students. There was a student who noted how proud his parents were of her because she was doing well in mathematical competitions; seeing her parents pleased and happy because of her performance motivated her to study mathematics. On the other hand, several students mentioned that someone in their families (their parents, their brothers, uncles) had a math-related job or degree, and that inspired them to study. See for example the next transcription:

Interviewer: What did your parents say when you told them that you wanted to study mathematics?

Student: What happens is that my dad he is a math teacher, then well... then he told me yes, it is a good choice. He encouraged me and asked me to make my best effort.

*Applications of mathematics.* There were four students who referred to moments in their school life where they found that mathematics could have many applications. The students claimed that this characteristic made them get interested in mathematics. The following is a transcript of one of these accounts:

Student: In high school a teacher played a video about how mathematics is everywhere, ... well it is also used in music and, I don't know, it called my

attention to know that there are many applications and that at the end, everything has to do with mathematics.

*Role models.* When we talk about role models we refer to people who serve as an example and inspiration to students, but who are neither their teachers nor their relatives. One student remembered her encounter with an astrophysicist. Apparently he was a source of inspiration for her:

Student: My dad knows a person who is an astrophysicist, in fact he studied here [in the National Polytechnic Institute], he is now at NASA...I would like to study astrophysics, I really like the outer space, see, I want to see [...]

## CONCLUSION AND DISCUSSION

In this project we are trying to answer the following research question:

*What factors motivates Mexican female students to choose mathematics as a career?*

Based on the previously presented preliminary results, we can say that there are three major factors that influence Mexican female undergraduate students to choose mathematics as a career:

- (1) To be aware of the fact that they are good at mathematics.
- (2) The influence of their mathematics teachers.
- (3) The influence of their relatives.

Our results are similar to those reported in previous research. For example, Eccles (2007) mentions the confidence that individuals have in their own intellectual abilities as a motivating factor for women to study STEM careers; on the other hand, Sjaastad, (2012) recognizes the big influence that parents, teachers and friends can exert on young people for them to choose scientific careers. A result that we found in the study and we have not seen reported in the literature is that mathematical competitions can be a place where students can acknowledge or confirm their mathematical skills.

The three identified factors contain elements that help students to identify and confirm the ownership of attributes (such as the ability to solve mathematical tasks), which in turn could trigger the construction of an identity as mathematics learner (Anderson, 2007). When this identity is constituted, choosing to study mathematics appears as a natural and well-suited option.

For instance, the situation where their classmates asked for help to do their homework, can be interpreted as a process where female students realize that they have certain mathematical abilities; when the teacher assigns extra tasks to the student, in a way is implicitly communicating that the student is special: she possesses qualities that others do not have. In our view, a good performance in

mathematical competitions can help students to confirm the ownership of such mathematical skills. These inputs that the female student receives may help to constitute the identity face known as *engagement* (Anderson, 2007), where students identify themselves as capable mathematics learners. On the other hand, noticing that some of your relatives have studied or perform some math-related job can support the creation of a mathematical identity compatible with one of the most important social groups to which you belong: your family. We believe that this type of influences from family members can encourage the student to imagine herself as a person that in the future could pursue a math-related career. Anderson (2007) refers to this aspect as the *imagination* face of identity.

We believe that it may be productive to continue exploring this theoretical perspective to support the development of our research. The next step in our research will be finishing with the data analysis and categorization of the results. Also, to delve deeper into the theoretical perspectives that connects the self and identity with career choice.

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