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THEY MADE HISTORY IN MATHEMATICS

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ABSTRACT

This article aims to verify the perception of mathematics undergraduates about the contributions and visibility of women in mathematics. This is a qualitative research, for which a questionnaire was produced on the Google Forms platform with eight questions, applied to fourth-year students of the Mathematics Degree course at a public university in the state of Pará, related to issues about gender and science. With the application of the questions, it was found that although the students recognize that women are part of the history of mathematics, few know them. In addition, because they are students in the last year of the course, it was noted that the female figure had little contact during the disciplines studied in previous years.

Keywords: History of Mathematics. Women in Mathematics. Degree in Mathematics.

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INTRODUCTION

This article is a continuation of the research entitled "Women in Mathematics: contributions and challenges" approved in 2020. This proposal comes from reflections of the research group of Didactics of Mathematics and Mathematics Education, in which the advisor professor realized that the theme could constitute a Scientific Initiation Project.

When we study Mathematics, we learn about the contributions of several scientists to its development and often, formulas and procedures are named after them, which demonstrates their importance. However, when we analyze these facts, we will realize that most of these well-known scientists are men and thus, as Garbi (2009) explains, the available mathematical knowledge has been gathered by males over the centuries.

In the field of Mathematics, particularly in the Full Degree in Mathematics, students have little contact with the life or even the work of women who contributed to the development of this area of knowledge. According to Silva and Rotta (2022), this fact occurs because much of the mathematical knowledge has been produced by male scientists. From this perspective, there is a naturalization of the gender issue in mathematics, as a result of the lack of contact between students regarding the participation of women in this science.

Despite the difficulties encountered in a society full of prejudices, women presented their share of contribution to the development of Mathematics and left their name engraved in history by breaking the paradigm that such science was only for men. As an example, we can highlight Hypatia of Alexandria, the first woman mathematician recorded in history; Sofia Kovalevskaya, prominent in the development of the Cauchy-Kovalesky Theorem; Emmy Noether, considered the "mother" of Modern Algebra; Marie-Sophie Germain, collaborated on the last Fermat's Theorem; Maria Gaetana Agnesi, contributed to the geometric construction of the so-called Agnesi curve.

From this perspective, we consider it important to focus on research on the contributions and visibility of women in mathematics and other areas of knowledge. Such a discussion makes it possible to expand discussions on gender equality, in addition to promoting inclusive and quality education.

Thus, we hope to contribute so that young students, taking a degree in mathematics, realize that they can ascend in their scientific careers and expand female participation in the field of mathematics, as well as in other scientific fields.

Thus, the present work sought to verify, through a questionnaire, the perception of undergraduate students in the last year of the Mathematics Degree course about the contributions and visibility of women in mathematics.

The organization of the article is structured as follows: Women and Mathematics, Methodological Paths, Results and Discussion, Final Considerations and, finally, the References.

WOMEN AND MATHEMATICS

Women, during a period of human history, were not only discouraged, but prohibited from dedicating themselves to the area of Mathematics. The society in which they lived did not allow them to attend college and their task was to take care of their family and home. Parents also kept their daughters away from contact with Mathematics, since it was considered a science only for men and thus, according to Garbi (2009, p. 419) "several of the best scientific schools in Europe, until the nineteenth century, simply did not allow female students to enter".

According to Souza and Fonseca (2010), the relationship between women and the production of science, particularly Mathematics, is little addressed, and it is necessary to analyze them in order to understand a little more about the History of Mathematics and the history of humanity itself. In her monograph, Nunes (2021) raised some points to be considered when dealing with the presence of women in mathematics. According to the author, when examining the trajectories of six mathematicians, the barriers they faced in their careers stand out. From her father's disapproval to the denial of access to higher education, her accounts reveal the arduous battle fought by these pioneers.

We agree with Nunes (2021) that these women and many others embody the crucial importance of female figures in the history of mathematics. Their invaluable contributions drive the development of the area and have led it to the level we find today. In addition, according to Nunes (2021), in Brazil, the highest levels of education were reserved for men and female access to higher education only began in 1881, but inequality of opportunities and prejudice limited entry until the 1960s. From 1985 onwards, with the expansion of private universities, women benefited the most, gaining greater access to all levels of education, including higher education.

In order to highlight women who have contributed to the field of mathematics, Jasen et al. (2018) conducted their research on three women: Hypatia of Alexandria, Emmy Noether, and Maryam Mirzakhani. Their work highlighted them as producers of knowledge, clarifying their contributions and relevance in the mathematical area. In addition to these, other women were also mentioned according to the contributions they made. Thus, in the following paragraphs, the women mentioned will be presented according to the authors mentioned.

The first woman mathematician recorded in history is Hypatia of Alexandria, born around 370 A.D., in addition to being a mathematician, she was a philosopher and astronomer. Hypatia's contributions were relevant to astronomy, as she developed instruments that were used in navigation and physics. She was also a professor at the university and in addition to having occupied the chair of Plotinus.

Another woman mathematician that Jesen et al. (2018) bring up is Emmy Nother, a German born in 1882. She is considered the mother of modern algebra, and has made contributions in this area with respect to fields and rings. Even with many difficulties to enter and remain in an academic career, Emmy Noether managed to earn her doctorate and later teach classes. Maryam Mirzakhani was also an important name in the history of women in mathematics. The Iranian mathematician born in 1977, contributed with studies on Riemann relations, where she was able to demonstrate several ways in which deformed versions of surfaces can be seen. His studies resulted, in 2014, in winning the Fields Medal, considered a Nobel Prize in Mathematics.

Despite having explained the contributions of the three mathematicians mentioned above, Jesen et al. (2018) cited names of other mathematicians who contributed to the area, such as:

> Sofia Kovalevskaya, prominent in the development of the Cauchy-Kovalesky Theorem; [...] Marie-Sophie Germain had great relevance for Fermat's last Theorem; Maria Gaetana Agnesi, contributed to Science with Agnesi's curved geometric construction. And today we have: Chanda Prescod-Weinstein, the first black woman astrophysicist at NASA; Chelsea Walton, considered a genius of today's algebra, Talithia Williams, a statistician; Christina Eubanks-Turner, the passionate about commutative algebra [...]. (p.03)

Studies like this are relevant for the names of these women to be known, showing that mathematical knowledge was not built only by men. In this sense, Teixeira and Costa (2008) conducted a research on women in the sciences, and the perception of physics undergraduates regarding their knowledge. According to the data from their research, it was noticed that students have few references of women who have contributed to science, and especially when it comes to Brazilian scientists.

The study by Teixeira and Costa (2008) revealed that, in general, the interviewees consider the participation of women in the scientific environment important, and agree that there are prejudices in this area in relation to women. The survey also revealed that respondents agree that men and women think and analyze reality differently from each other. This way of thinking is not necessarily seen in a negative way, since the interviewees consider that these differences are part of the human being and are also related to evolution. On the other hand, there was a percentage of 20% of respondents

and 14% of respondents who consider that there is a difference in intellectual abilities between men and women, however, the question does not direct the answers to indicate in which gender they think cognitive abilities are lower.

In this sense, we directed this research to verify the perception of mathematics licentiate students of the contributions of women in the area. The methodological paths adopted in this study are indicated below.

METHODOLOGICAL PATHS

The present study was developed based on a qualitative, descriptive approach. In the view of Denzin and Lincoln (2006), qualitative research involves an interpretative approach to the world, and seeks to understand phenomena in terms of the meanings that people attribute to them.

For the progress of the research, a search was initially carried out for authors who investigate the contributions of women in mathematics. The survey of these authors occurred in books, dissertations, theses, articles, magazines, among other means in the perspective of substantiating the investigation.

In the next moment, a questionnaire was produced on the *Google Forms* platform with eight questions related to questions about gender and science and one question of an academic nature to identify the students' study shift, since it was applied to students in the last year of the mathematics degree course at a public university in the state of Pará. The questions of the questionnaire applied can be seen in Table 1 below.

Table 1. Questions from the questionnaire applied to mathematics students

Academic question
1. In which shift do you study? ( ) Morning ( ) Afternoon ( ) Night
Gender-Related Questions in Math
2. Which male scientists contributed to the development of mathematics? Name at least 5 mathematicians you remember
3. Do you consider that women have also contributed to the development of mathematics throughout history? Justify your answer.
4. How many women participated in the construction of mathematics do you know? Name these women.
Questions about women in mathematics and their contributions
5. Would you know who was the first woman in the history of humanity to contribute to mathematics? If so, name it.
6. Which mathematical scientist became known for his or her contributions of fundamental importance to the fields of theoretical physics and abstract algebra? Name your name, and if you know, make some contributions.
7. Can you say who was the first woman to receive the highest award in mathematics, the FIELDS medal? If so, could you mention her name and say what her research was about?
8. Could you say who was the French mathematician, physicist, and philosopher with fundamental contributions to number theory and elasticity theory, and who discovered a family of prime numbers? If so, mention his name and, if you know, comment on what your discovery implied.
9. Would you be able to say who was the Mathematics that is recognized as having written the first book that dealt simultaneously with differential and integral calculus. She wrote in Latin the work

"*Propositiones philosophicae*" (Philosophical Propositions), published in Milan in 1738. If you do, write her name.

Source: Prepared by the authors

The data obtained in the research were collected through written records in the proposed protocol. Subsequently, they were described and analyzed with the perspective of verifying the perception of the investigated subjects about the contributions and visibility of women in the area of mathematics.

The results obtained are described below, as well as the discussions.

RESULTS AND DISCUSSIONS

According to the data collected in the questionnaire applied, it is possible to have a perception of the students' knowledge regarding the role of women in mathematics. To this end, this topic will be structured according to the questions that were asked, presenting and analyzing the answers obtained in each question.

The first question asked in the questionnaire aimed to identify in which shift the students study. From the results obtained, it was observed that students from the three shifts were part of the research, 25% in the morning, 25% in the afternoon and 50% in the evening. It was noted that half of the interviewees are from the night shift, and these students have a different profile from the other shifts. This is because they are usually older students, and are already inserted in the job market.

From this moment on, the questionnaire is directed to questions focused on the theme of this article. Therefore, the following three questions are related to gender issues in the field of mathematics. The other questions are specific, aimed at women who have contributed to the area.

Thus, he began by asking "Which male scientists contributed to the development of mathematics? Name at least 5 mathematicians you remember." The answers obtained are shown in Figure 1 below.

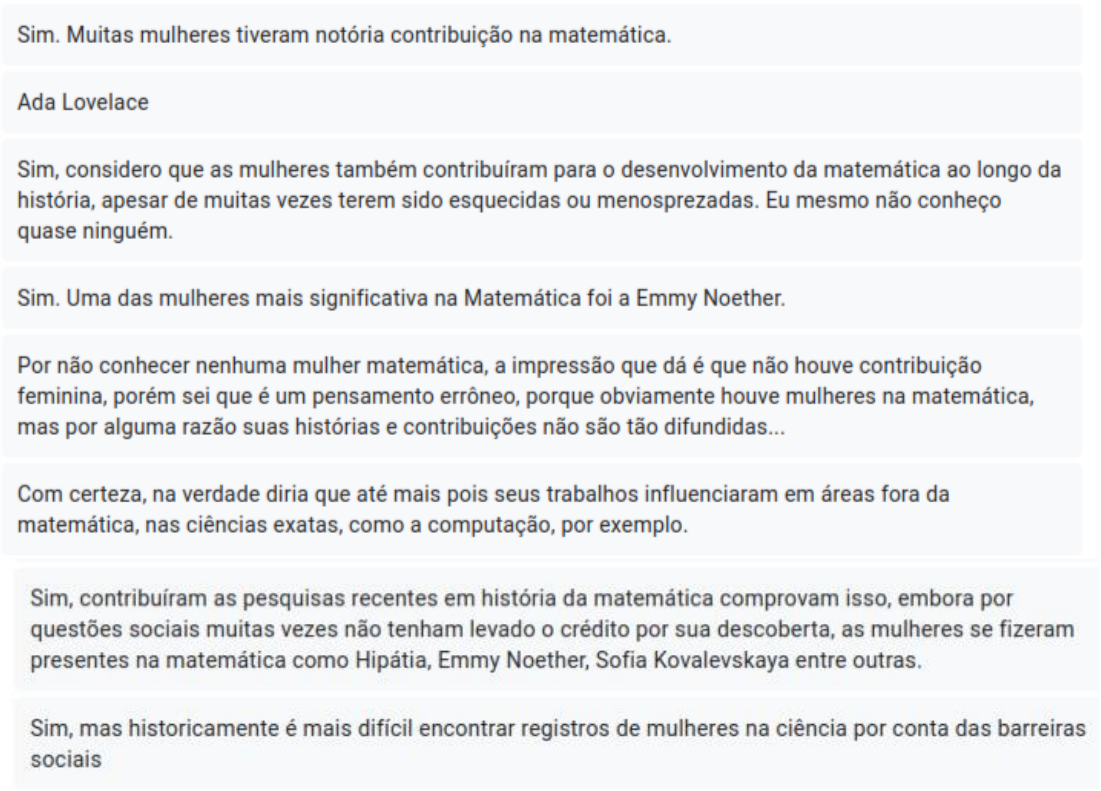
Figure 1. Mathematicians known to students

Source: The authors (2024)

According to the data obtained, it was possible to notice that the students had no difficulties in mentioning the names of the mathematicians. In addition, among the answers there is a variety in relation to the names presented. As shown in Figure 1, 18 different mathematicians were presented.

The next question was: "Do you consider that women have also contributed to the development of mathematics throughout history? Justify your answer." Figure 2 presents the answers presented by the students.

Figure 2. Students' response on women's contribution to the development of mathematics throughout history



Source: The authors (2024)

Most of the answers confirm that women have contributed to the development of mathematics. However, almost no answer has a justification based on scientific research, only one of the answers that was given said "[...] recent research in the history of mathematics proves this [...]". The students themselves realize that social issues are related to this lack of recognition of women in the field of mathematics. The answer quoted above continues "[...] although, for social reasons, many did not take credit for its discovery [...]". Similarly, another student cites "Yes, but historically it is more difficult to find records of women in science because of social barriers."

As a consequence, even in the academic environment, students have little contact with women who were notorious during the development of mathematics. This can be seen in one of the answers that says "Because I don't know any women mathematicians, the impression it gives is that there was no female contribution, but I know that it is an erroneous thought, because obviously there were women in mathematics, but for some reason their stories and contributions are not so widespread...".

In addition, few justifications contained women's names as examples. In this sense, the next question was intended to identify whether the students were aware of women who contributed to the field of mathematics, with the question "How many women participated in the construction of mathematics do you know? Indicate the names of these women.", Figure 3 below presents the answers to this question.

Figure 3. Examples of women who participated in the construction of mathematics according to the interviewees

Source: The authors (2024)

The question asked did not ask for a number of examples of women mathematicians so that the interviewees could feel free to put the names known or not. When analyzing the answers, one can notice the difference in relation to the question of the mathematicians who contributed to mathematics. The first is that when you ask for names of mathematics, answers such as "I don't know" or "I don't know any" appear. Another difference is that the interviewees who mention the names cite on average only two names, except for one, who managed to name nine names, more names than mathematicians, requested in the first question.

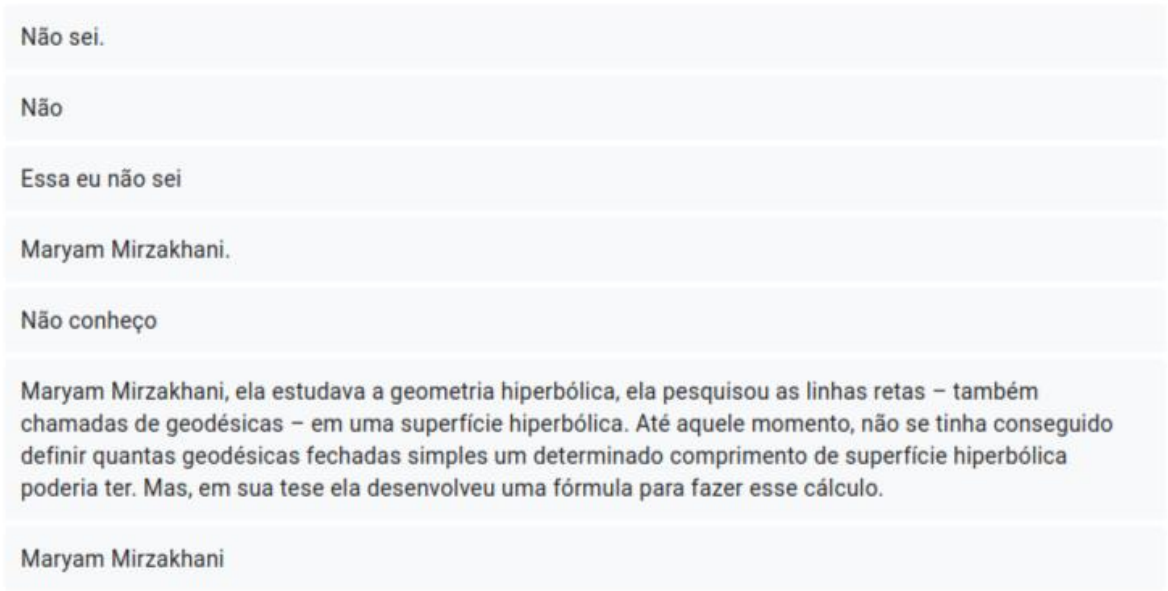
It is worth noting that of the names mentioned, not all were mathematicians, such as Marie Curie, who was a physicist and chemist with a great contribution to science. One of the answers also highlights the knowledge of women mathematicians who have worked in the area of programming. Among these answers, 18 mathematicians were mentioned.

The other questions in the questionnaire are more specific about mathematics and their contributions throughout history. Therefore, the next question was "Would you know how to answer who was the first woman, in the history of humanity, to contribute to mathematics? If so, name her." Most of the students investigated correctly mentioned the name of the mathematician Hypatia of Alexandria, however, it is still possible to see that many did not know how to answer. Hypatia of Alexandria is considered to be the first woman mathematician in history, her contributions to mathematics are related to the studies of geometry, algebra and astronomy.

Next, the question asked was "Which mathematical scientist became known for her contributions of fundamental importance to the fields of theoretical physics and abstract algebra? Name your name, and if you know, make some contributions." According to the data obtained, it was observed that in addition to answers such as "I don't know", they also had answers considered uncertain, such as "I don't know, but I kick Emmy Noether [..]". Other answers were more direct, with only the name of the scientist in question. The following answer stands out: "Emmy Noether, considered the creator of modern algebra, was able to prove two theorems that are essential to the theory of relativity by solving the problem of conservation of energy that is known to physicists as "Noether's theorem". This was the only answer that presented in its justification the scientist's contributions, citing how she is known.

Next, the next question sought to verify the knowledge regarding the most recent contributions and recognitions of women in mathematics, so it was asked "Can you say who was the first woman to receive the highest award in mathematics, the FIELDS medal? If so, could you mention her name and say what her research was about?" The answers obtained are highlighted in Figure 4 below.

Figure 4. Answers about the first woman to receive the FIELDS Medal



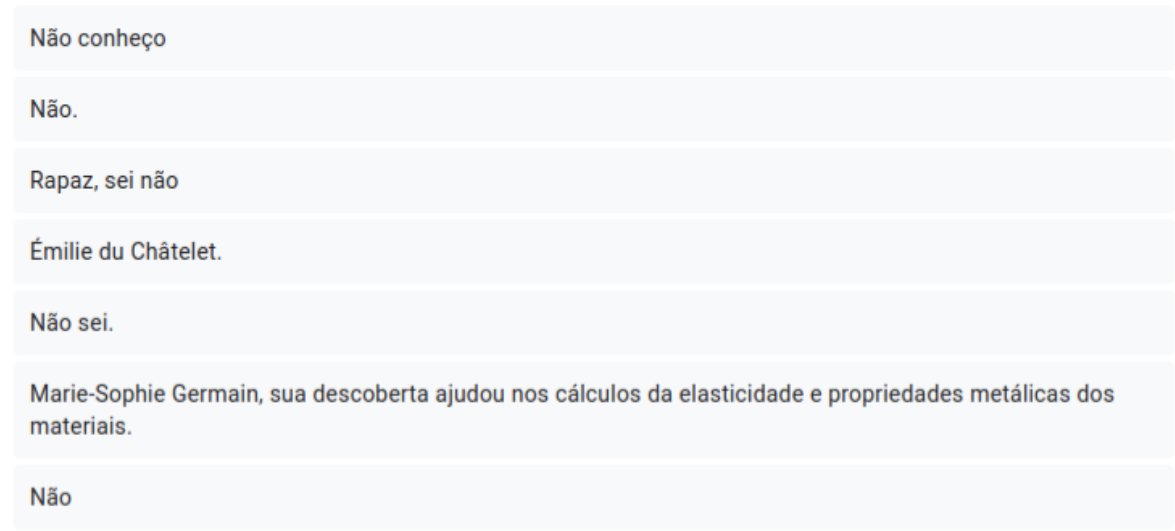
Source: The authors (2024)

Even though it is a question referring to a more recent event historically, the number of answers containing "I don't know" or "I don't know" is considerable. As in the previous question, the interviewees who were able to answer the name did not cite, for the most part, the complete justification for what Maryan Mirzakhani's research was about. Only one response presented the complete justification for the research that led her to win the

award. It is worth noting that Maryan Mirzakhani's award opened a discussion about female underrepresentation in mathematics, in addition to becoming an inspiration for new generations of women to pursue careers in scientific areas.

Subsequently, the question presented to the interviewees was "Could you say who was the French mathematician, physicist and philosopher with fundamental contributions to number theory and elasticity theory, and who discovered a family of prime numbers? If so, mention his name and, if you know, comment on what your discovery implied." Figure 5 shows the answers of the interviewees to this question.

Figure 5. Answers about the French mathematician, physicist and philosopher with fundamental contributions to number theory and elasticity theory.



Source: The authors (2024)

According to the answers presented, most of the interviewees did not know how to answer this question. One of the students replied "Émilie du Châtelet", who despite having been a French mathematician, physicist and philosopher, is not the woman to whom the contributions made in the question refer. Only one of the students correctly presented the name of the scientist and the justification for the implication of her studies, saying "her discovery helped in the calculations of the elasticity and metallic properties of the materials".

Finally, the last question presented to the interviewees was "Would you be able to say who was the Mathematics that is recognized as having written the first book that dealt simultaneously with differential and integral calculus. She wrote in Latin the work "*Propositiones philosophicae*" (Philosophical Propositions), published in Milan in 1738. If you know, write her name."

In general, the answers show that the students do not know who the question is about, since they pointed out as answers "I don't know how to say" or "This is difficult too, I

don't know". Few investigated answered correctly the name of Maria Gaetana Agnesi, and one of them also mentioned knowing the history of mathematics.

In general, it is perceived that female representation is little highlighted in the academic environment. This is because, when analyzing the answers given by students in the last year of the mathematics degree course, few are those who demonstrate the minimum of knowledge. In addition, it is observed that students who know the women who contributed to the field of mathematics know them vaguely, without being able to explain or present the implications and contributions of their studies.

Having described the results, the next section addresses the final considerations established from the research.

FINAL CONSIDERATIONS

By applying the research questionnaire in order to analyze the perception of mathematics undergraduates regarding the contributions and visibility of women in mathematics, the need for greater visibility and recognition of women's contributions in this field was clarified. It can be noted that students understand that women are part of the history of mathematics, but there is still a lack of depth to be aware of their contributions.

It is also noteworthy that the students who participated in the interview are in the last year of the mathematics degree course. According to the analysis of the answers, it is perceived that there was little contact during the course with the female figure within the disciplines studied. In this sense, it is of paramount importance to research that seeks to disseminate the work and contributions that women have made in the field of mathematics. Thus, we can say that the greater the visibility of women who have been and are part of the history of mathematics, new generations of women will be inspired to enrich this area, contributing to gender equality.

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