Past experiences and the image of mathematics: A study with secondary education students

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Abstract: This study examines the relationship between the past experiences of secondary education students with their current image of mathematics. It is based on the premise that the image of mathematics is formed through experiences mediated by school, parents, peers, and society. Drawings and interviews were used to explore these experiences. The results reveal three outcomes: those where past experiences have a clear influence on their current image of mathematics, cases with no observed relationship, and instances of an ambiguous connection. The findings highlight the remarkable influence of prolonged and constant events, such as the period during the pandemic and parental influence.

Keywords: Past experiences; Image of mathematics; Drawings; Secondary education students

INTRODUCTION

The prevalent perception students associate with mathematics is often linked to recurrent terms: 'numbers,' 'operations,' 'difficulty,' 'formulas,' 'boredom,' and 'utility' (Hatisaru & Murphy, 2019; Lim & Ernest, 2000; Rott et al., 2023; Towers et al., 2017; Yazlik & Erdogan, 2018). This phenomenon can be attributed, in part, to the abstract nature of mathematics, which requires a deeper understanding and more extensive study time compared to other subjects (Basar et al., 2002, as cited in Yazlik & Erdogan, 2018).

Consequently, this negative perception extends to the image of mathematicians, which is a matter of significance as some students may aspire to pursue a career in this field. In fact, students commonly associate mathematicians primarily with teaching roles (Aguilar et al., 2016; Picker & Berry, 2000). Mathematicians are often viewed as solitary individuals, unsociable, reserved, and always engrossed with numbers. There is a common belief that they are highly intelligent although

somewhat eccentric (Ucar et al., 2010). These characteristics, for the most part, are not appealing to students.

All this information has been gathered from different research studies in the field. These studies provide us with an insight into the dynamics present in the classroom and allow us to identify deficiencies in the education system. In addition, knowing the negative perceptions or obstacles students face in mathematics, as well as their origin, allows educators to address those specific challenges.

The main objective of the present study is to explore the mental images and significant past experiences related to mathematics among high school students. It seeks to determine whether these prior experiences have any influence on the students' current perceptions of mathematics. Although the study does not aim to establish definitive conclusions due to the limited number of participants, it seeks to gain an initial understanding of how past experiences may affect high school students' present perception of this academic discipline.

LITERATURE REVIEW

In this review, the conceptualisation of the 'image of mathematics' is initially addressed. Subsequently, related research is explored, with an emphasis on those that use drawings as an analytical tool. The key results of these studies are presented, and finally, students' previous experiences with mathematics are examined, recognising them as the root of current perceptions.

The Image of Mathematics

Lim & Ernest (2000) formulated a definition of the image of mathematics based on the concept of an image, conceived as a mental representation. However, their approach goes beyond mere ideas or concepts, encompassing fragments of sensory, emotional, and cognitive experiences. Over time, several authors have proposed similar definitions of this construct, occasionally associating it with the concept of 'disposition' (Lane et al., 2016).

Lane et al. (2014) defined the image of mathematics as “a mental representation or view of mathematics, presumably constructed as a result of past experiences, mediated through school, parents, peers, or society” (p. 881). This definition shares similarities with that presented by Lim & Ernest (2000) and has been widely adopted in previous research (Lane et al., 2016; Lane, 2017; Hatisaru, 2020a; Hatisaru, 2020b; Hatisaru & Murphy, 2019). Therefore, this definition will be employed as the conceptual framework within the context of the current study.

Using drawing as a research method

Various studies employ drawings as a means of data collection. It has been demonstrated that drawings provide students with a way to express their emotions and thoughts which they sometimes find challenging in oral or written communication (García-González et al., 2023; Lin,

2022; Turgut & Turgut, 2020). Unlike questionnaires, drawings lack a predefined structure and do not involve the complexity of language for comprehension (Stiles et al., 2008). “The reviewed literature has shown that drawings of students contain rich information on their thoughts about teaching and learning of mathematics" (Rott et al., 2023, p. 4).

Recent studies have employed the Draw a Mathematics Classroom Test (Hatisaru, 2020a; Hatisaru, 2020b; Rott et al., 2023) and the Draw A Mathematicians Test (DAMT) (Berry & Picker, 2000; Hatisaru & Murphy, 2019; Lin, 2022; Picker & Berry, 2000; Yazlik & Erdogan, 2018), both with a brief description of the drawing or open-ended questions. Other research has utilised Likert-type scales (Lane et al., 2016; Stiles et al., 2008), semi-structured interviews (Lane et al., 2014; Lim & Ernest, 2000), or simply asked participants to draw and write about it (Lee & Zeppelin, 2014; Turgut & Turgut, 2020).

Finally, it is relevant to mention the work of Towers et al. (2017), who instructed participants to illustrate their emotions while engaging in mathematics, resulting in diverse and informative experiences. This study not only enriches our understanding but also serves as a fundamental source of inspiration for the current research.

Now, the findings of the previously mentioned research are presented.

Mathematics teachers and classes in the minds of students

There is an abundance of literature addressing students' perceptions of their mathematics teachers. Firstly, the teacher is often perceived as an authoritative figure, placing students in the role of passive recipients (Rott et al., 2023). According to students' perceptions described in Hatisaru (2020a), "the teacher explains and demonstrates the subject and/or solves routine questions. Students sit at desks and listen to the teacher who stands in front of the class and lectures" (p. 209). Similarly, other studies identify students' responses as indicative of a traditional educational approach where the teacher plays the primary role (Hatisaru, 2020b; Lee & Zeppelin, 2014; Turgut & Turgut, 2020).

Mathematics teachers play a crucial role in motivating students by providing emotional support (Skaalvik et al., 2015); however, it is noteworthy that the proportion of students who recall negative experiences with their teachers is four times higher than those who remember positive ones (Lane et al., 2014; 2016).

In mathematics classes, students typically work individually, engaging in routine arithmetic or algebraic operations that have a single correct answer. Commonly used materials such as books, notebooks, pencils, and chalkboards remain the primary elements in the learning and teaching process (Hatisaru, 2020a; Hatisaru, 2020b; Lee & Zeppelin, 2014; Rott et al., 2023; Turgut & Turgut, 2020).

When students are asked about the connection between mathematics and their everyday lives, the responses often lack detailed elaboration. Many students limit their mentions to examples such as grocery shopping, and some even associate school assignments as an activity related to mathematics (Stiles et al., 2008; Towers et al., 2017; Turgut & Turgut, 2020).

As a result of these data, it becomes evident why the perception of mathematics remains negative. These results underscore that, despite educational reforms, a traditional teaching approach in mathematics persists (Towers et al., 2017). This leads us to the conclusion that a change in how mathematics is approached in the classroom is necessary. Turgut & Turgut (2020) emphasise the importance of promoting mathematical activities outside the classroom and ensuring teachers receive training in this regard.

Researchers emphasise the importance of developing problem-solving, argumentation, and critical thinking skills in students. This involves selecting tasks that cognitively challenge students and that also teach them to use errors as learning opportunities. Additionally, there is a highlight on the need for students to establish connections between different mathematical representations, such as symbols, diagrams, and verbal problems, to construct meaning through reflection. The importance is underscored for students to perceive the utility of mathematics and understand its value, thereby transforming mathematical thinking and reasoning into an integral part of their lives (Hatisaru, 2020a; Hatisaru, 2020b; Towers et al., 2017; Yazlik & Erdogan, 2018).

Up to this point, the focus on drawings and the results has primarily centred on didactic aspects. However, our main interest lies in the experiences that lead to the formation of each student's current perception of mathematics, according to the definition by Lane et al. (2014). The following section presents the results obtained in this context.

Experiences of the students

According to the consulted research, past experiences with mathematics have had a significant impact on individuals' image of mathematics (Lane et al., 2014; Towers et al., 2018). Those who achieved high marks tend to experience higher levels of enjoyment, motivation, and appreciation for mathematics. In contrast, individuals with negative memories often have a less favourable self-image and higher levels of anxiety, particularly among women (Lane et al., 2016). Additionally, it has been observed that parents' perceptions of mathematics also impact their children's anxiety levels. Parents working in mathematics-related fields tend to raise children with lower levels of anxiety (Lane, 2017).

An intriguing observation is that students with positive experiences tended to be less detailed in their narratives, whereas those with negative experiences appeared to be more emotional and descriptive in their accounts (Lane et al., 2014; 2016; Towers et al., 2017).

The existence of both positive and negative experiences related to mathematics can be appreciated. The positive attitude of students toward mathematics is mostly attributed to their competence in numerical sense or external validation, such as support from their parents or teachers, outstanding marks, and their ability to solve problems quickly. Some examples of these statements include: "(I feel) proud. Because I do a really large number for division… and multiplication, also sum" and "I like it [addition] and I do it really fast" (Towers et al., 2017, p. 170).

When an initially negative relationship transforms into a positive one, the support and backing provided by both teachers and peers are highlighted. On the other hand, the reverse phenomenon is also observed; some students mention that the common practise of providing answers without showing the process does not help them learn. Others express concern about the pressure they feel when thinking about their future, especially when teachers emphasise that mathematics is essential for creating job opportunities and that without it, finding employment could be challenging; these words work in the opposite direction of what is expected (Towers et al., 2017).

Finally, regarding the negative relationships that students currently maintain with mathematics, experiences emerge that include comparing themselves to others they perceive as more competent students, as well as the belief that mathematical skills are innate and, therefore, cannot be improved, leading to inaction (Towers et al., 2017). While the first aspect is widely recognised beyond the field of mathematics education, the second point reveals a belief in which teachers can positively influence and demonstrate that it is not necessarily true. Therefore, it is essential to continue exploring students' experiences in this context.

Within this framework, the following research questions will be addressed: 1) What are the past experiences of secondary education students related to mathematics? 2) What is their current image of mathematics? and 3) Does exist a relationship between the significant experience and the actual image of mathematics?

METHOD

First, a concise description of the participants is provided, specifying the number of individuals at each stage of the study. Next, a detailed research design is outlined, including the data collection instruments used and the selection criteria, concluding with a brief exposition of the applied analysis techniques.

Participants

In the first phase of this study, which involved creating drawings, 73 (25 men and 48 women, 16-18 years old) secondary education students in the city of Puebla, Mexico, participated. These students were in their final year of secondary education, which is relevant for this study. For the second phase, which included semi-structured interviews, nine students were selected for the interviews, and seven of them accepted the invitation to participate (one man and six women).

Research Design

The research follows a qualitative approach with a descriptive-exploratory scope.

According to Lane et al.'s (2014) definition, the image of mathematics evolves from past experiences. To gather information about these past experiences, we considered instruments previously used by other researchers, such as the Draw a Mathematics Classroom Test (Hatisaru, 2020a; Hatisaru, 2020b; Rott et al., 2023) and the Draw A Mathematicians Test (DAMT) (Berry & Picker, 2000; Hatisaru & Murphy, 2019; Lin, 2022; Picker & Berry, 2000; Yazlik & Erdogan, 2018). Inspired by these tools, we now propose asking students to draw a significant experience related to mathematics.

The use of drawings offers advantages not found in other metrics, as it not only facilitates the recall of past experiences but also serves as an effective preliminary activity to introduce an interview (Goldin, 2000; Ellis et al., 2011; Ellis et al., 2013; Tran et al., 2023). This represents a significant advantage, as the interview will be integrated into this research methodology.

Rott et al. (2023) have raised criticisms regarding the limitations of the use of drawings, highlighting primarily the subjective interpretation by researchers. Guided by the recommendations of Mitchell et al. (2011), a proposed worksheet confronts this challenge by inviting students to narrate their experiences alongside the drawing, integrating it as a key element in their mathematical autobiography. Mathematical autobiographies constitute a valuable source that allows reflection on the impact of teachers' actions and words on the learning process, and how these can have lasting effects on students (Ellsworth & Buss, 2000; Hobden & Mitchell, 2011).

The instrument created and utilized is exemplified in the Appendix.

Subsequently, the drawings were preliminarily classified according to Lane et al.'s (2014) definition, which highlights that past experiences shape the perception of mathematics and are mediated through school, parents, peers, or society. A subcategory was established to encompass the broad spectrum of the school environment. The classifications are outlined in Table 1.

Table 1. Categorisation of students' past experiences

Category	*Description*
School	
Subject	Past experience related to the school subject of mathematics.
Teacher	The teacher has a significant influence on the past experience.
Parents	Parents have a significant influence on the past experience.
Peers	Peers have a significant influence on the past experience.
Society	Society or a social event has a significant influence on the past experience.

Next, two drawings were chosen from each category: one representing a positive event and another representing a negative event. In the 'peers' category, it was only possible to select the negative event, as there was not a positive one. The criterion adopted was to select drawings that showed a

greater correspondence between what was depicted in the drawing and what was described in the accompanying narrative.

With the aim of delving into the image that students have of mathematics and its possible relationship with past experiences, semi-structured interviews were conducted. The interview was scheduled to take place with the nine selected students; however, two of them later decided not to participate. Consent was obtained from both parents and students to conduct the interviews.

The initial question posed to the students was, "What do you imagine when you hear the word mathematics?". Building upon this question, further inquiries were pursued to delve into the origins of this perception and ascertain whether it correlated with the experiences they had depicted in their drawings a week prior.

Data Analysis Technique

The data analysis method employed involves carefully examining the representations in the drawings and interpreting them, along with triangulating the narratives (Mitchell et al., 2011), to determine whether the depicted event is perceived positively or negatively by the students. Each drawing is then classified into one of the predefined categories. Once this classification is complete, the drawing that best fits both the representation and the narrative is selected for a more detailed analysis.

Regarding the analysis of the relationship between past experiences and the current image, it is crucial to ensure that the constructed mental image has a meaningful connection with the students' experiences. This analysis is divided into three categories: 1) a clear relationship exists, 2) no relationship exists, and 3) the relationship cannot be determined.

RESULTS AND DISCUSSIONS

What are the students' past experiences and perceptions of mathematics? Three situations can be identified: one where past experiences depicted have a clear influence on the formation of their image of mathematics, another where no relationship is observed, and a final scenario where the relationship is ambiguous, requiring more information to determine it.

Next, each of the three situations is described in a section, and in each of them, the drawing and a snippet of the interview of each student are presented as evidence. The interviewer is identified as 'I', and each student is represented by a different letter.

Influence of Past Experiences Depicted on the Image of Mathematics

In the following two cases, the impact of past experiences is clear. Student 'S' shared an experience categorized under the 'Society' category. Student F's experience is situated within the 'Parents' category. Both identified as negative event.

Figure 1. Drawing by Student ‘S’ (female). Category: society - negative

According to Table 1, the category ‘Society’ refers to society or a social event that has a significant influence on the past experience. In the case of student S, the social event is the pandemic, although the study was conducted in 2023, the impacts of the pandemic are still evident. In her drawing (Figure 1), she appears in front of the virtual class with her face turned sideways and her hands on it, which could signify defeat or frustration due to a lack of understanding of the topics.

According to the interview (see below), before secondary school, she considered mathematics to be innate, but now she acknowledges that mental processes are necessary.

I: What do you imagine when you hear the word mathematics?

S: Mental processes.

I: Do you feel like your mind is going through a process?

S: Yes, calculations. Well, in calculations, my mind works, follows a process to arrive at the result, and also devises strategies to make it easier or complicate it further.

I: How long have you had this perception of 'mental processes'?

S: Since secondary education.

I: What did you used to think about mathematics before?

S: Well, I used to think that mathematics, internally within me, just happened on its own, I mean, I didn't have to put in any effort or anything. It felt easy, like solving problems or conducting research. It was about taking what you already knew and applying it.

I: So, I assume with secondary education, after this pandemic period, you see it as more...?

S: Yes, more elaborate.

I: Did you make any decisions or change your thoughts about mathematics?

S: In terms of my thoughts, yes. I used to think that understanding mathematics came easily to me, but now I realise it's not just about luck, it's about really studying it. If you don't study, it's not easy.

Her current perception of mathematics has been influenced by the difficulty she experienced in understanding the topics. This change of beliefs is understandable due to the type of school mathematics she deals with, in addition to the fact that at this school level, an attempt is made to develop a more robust mathematical thinking in students.

She mentioned that her mind undergoes a process to arrive at a result, and this process is not automated; it requires effort, actually. This actual effort she experiences is not pleasant, as it implies that mathematics is not innate to her, a characteristic also found in the research by Hatisaru & Murphy (2019).

Figure 2. Drawing by Student ‘F’ (female). Category: parents - negative (translation: belt)

In the case of student 'F', her drawing (Figure 2) represents a past experience based on coercion to achieve her learning. In the image, the figure of her father, larger in comparison to her, threatens her with a belt, while she shows a sad expression on her face. According to the interview (see below), it is known that this threat was aimed at her learning the multiplication tables. This case highlights a dynamic where punishment or threats are used as tools for learning.

I: What do you imagine when you hear the word mathematics?

F: Lots of numbers and additions, like a whiteboard full of numbers that I don't understand very well.

I: Where do you think this perception or vision you have comes from?

F: Well, addition, because it always seemed easier for me. My parents have always put a lot of pressure on me regarding school, and in mathematics, like, I was good at one part but not the other. They used to say, “What you don't know is the most important, so you're not good at mathematics”. So, when I see the whiteboard full of things I don't understand, I feel like those are the vital things I just didn't get when I was little, and they are the most important ones. I find them a bit harder now.

I: Do you think this perception you have of mathematics is related to the experience you went through?

F: Yes, a lot.

I: How much influence do you think it has?

F: Well, for me, it was precisely the multiplication tables that I didn't know, and I vividly remember it was 8 times 7. I remember that day I, well, I've always been quite teary, so I was crying because I wanted to go to sleep; it was already late. But my dad insisted, “No, you're going to learn the entire eight times table”.

In Mexican culture, parental punishment is a common experience in basic school levels. Unfortunately, many students go through these types of situations under the mistaken belief that punishment is an effective way to gain knowledge. Student F's past story highlights the cultural influence and traditional educational practices that can affect students' learning experiences. Furthermore, this finding echoes the experience reported by parents in Canada (Towers et al., 2018), where parental statements significantly influenced self-perception regarding mathematics. This confirms that interactions with parents are indeed a determining factor.

The past experience of student ‘F’ underscores the importance of considering personal context and individual experiences when analyzing one's perception of mathematics.

No Relationship between Experiences Depicted and the Image of Mathematics

In this section, three cases are presented where there is no connection between the experience depicted in the drawing and the image of mathematics, however, there is indeed a connection with past experiences.

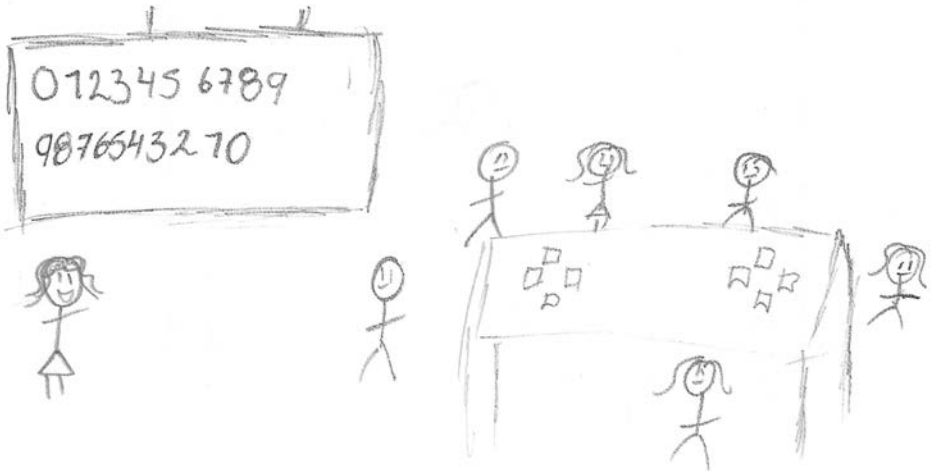

Figure 3. Drawing by Student 'G' (female). Category: society - positive

The first case involves student 'G', whose drawing was influenced by a literacy campaign she was participating in. Student G drew a moment when she was teaching mathematics to a community (Figure 3). In her drawing, she appears with a smiling face in front of the blackboard, where there are two series of numbers, from 0 to 9 in ascending and descending order. In front of her, there is a group of people, three women and three men, surrounding a table that seems to have didactic material, possibly related to the order of numbers.

She accompanied her drawing with the narrative "It means a lot to me because when you arrive in the community, you realize how vital mathematics is in life". Based on the interview, we consider that with this message she wanted to convey her happiness in being able to help others learn mathematics, and in doing so, she herself reflects on the importance of mathematics in everyday life.

In the following interview excerpt, the answer to the fundamental question becomes apparent. The student confirms that her perception of mathematics is shaped by what she has learned in school (past experience), yet not from the experience depicted.

> I: What do you imagine when you hear the word mathematics?
>
> G: I imagine lots of numbers, many, and a graph - I forgot its name - a graph, a cartesian plane, and a parabola.
>
> I: Do you know where this vision comes from?
>
> G: The part about the parabola, I feel it comes a lot from my second year of secondary education when we studied functions, and the numbers, it's like the graph appears and all the numbers are around it. I feel like all the numbers come from previous years, from elementary school, and from mathematics exercises and such.

I: What was your perception before the campaign?

G: They used to be very challenging, and they still feel challenging, but you approach them from a different perspective because you start to see how they can be useful in everyday life or what they are used for, and so on.

Although the student mentions that mathematics remains complex for her, a view shared by other students who also find mathematics difficult (Lim & Ernest, 2000; Hatisaru & Murphy, 2019), her perception of the utility of mathematics did change, as shown at the end of the conversation. It is inferred that performing basic operations did not seem like a significant achievement to her, or she did not see the true importance of knowing how to perform them. However, her appreciation for these basic concepts changed drastically, and she now views them as a necessity and, therefore, useful in daily life. Such experiences could be useful in influencing the perception of the utility of mathematics.

Figure 4. Drawing by Student ‘A’ (female). Category: teacher - negative

Student 'A', in her drawing (Figure 4) depicted a moment when she experienced coercion by her teacher. In the drawing, the figure of her teacher is larger than hers; both are standing next to the desk, and on it, there is a notebook with the operation: 4+3=9. She describes in the narrative, "One day, the sum of 4+3 resulted in 9 for me, but no matter how many times I checked, it still came out as 9". The teacher yelled the (correct) result to her, and at one point, began hitting her on the forehead with an eraser.

Moreover, in the following excerpt, it is evident that her initial perception of mathematics is not related to the drawing, but rather to her past school experiences, particularly the learning of fractions.

I: What do you imagine when you hear the word mathematics?

A: Fractions

I: Why specifically fractions?

A: Because they were very challenging for me, well, they still are. It's like they are not my friends.

The case of student ‘A’ aligns with the cases described in Berry & Picker (2000) regarding the feeling of threat experienced by students from their mathematics teacher, with the difference that, unlike those cases, student ‘A’ actually experienced physical aggression, the hit on her forehead. Perhaps the fact that she didn't get the correct result despite her revisions led the teacher to become angry, or to give up and provide the answer, reminiscent of the "Topaze Effect" (Brousseau, 1986). Along with this, there appears to be poor emotional management, resorting to hitting the student. Without condoning the teacher's actions, it should be noted that emotional regulation is an area that is not very developed among the Mexican teaching community.

Figure 5. Drawing by Student ‘P’ (male). Category: subject – positive

The third case in this section falls under the 'Subject' category, representing a positive event. Student 'P' recounts an experience which involved an exam on limits. He describes feeling a burning sensation in his head due to all the effort. In the picture (Figure 5), we can observe this sensation depicted as flames above his head while he is taking the exam, with a focused expression on his face. Afterward, upon passing, he feels proud of himself, indicating a positive experience.

Student 'P' answered "operations" to the first question of the interview (see below). He further explained that these operations are linked to real-life situations. When asked about the origin of

this perspective, he shared his experience working in construction, where he sees the practical application of mathematics in tasks like mixing concrete and ensuring precise measurements for different structures.

> I: What do you imagine when you hear the word mathematics?
>
> P: Like operations, I don't know, when I go to buy something, it's like I feel that we use math throughout life, so I relate them to everything.
>
> I: If you were to define mathematics in one word, what word would you use?
>
> P: Problem-solving
>
> I: What do you feel has influenced this vision you have the most?
>
> P: I don't know, well, I work in construction, and I feel like for making mixes, cement, you have to add a specific amount so that the mixture thickens depending on, for example, the wall or foundations, all that, well, you apply it.

However, there seems to be no correlation between the drawing experience (the exam) and his perception of mathematics. He does not consider the exam as a turning point, and the operations he mentions mostly pertain to his daily routines rather than involving complex concepts like limits.

He mentioned experiencing mental effort, a phenomenon previously documented in earlier research (Towers et al., 2017). He described this effort positively, comparing it to the adrenaline felt in competitions. This contrasts with 'S,' who perceives mental effort negatively.

Similarly to the previous case, this instance highlights the connection between mathematics and real-life activities, emphasizing the practical utility of mathematical concepts.

Ambiguity in the relationship

In this final section, we examine three cases where additional information is required to ascertain the influence of the depicted experiences on students' perceptions of mathematics. However, it cannot be definitively concluded that there is no connection.

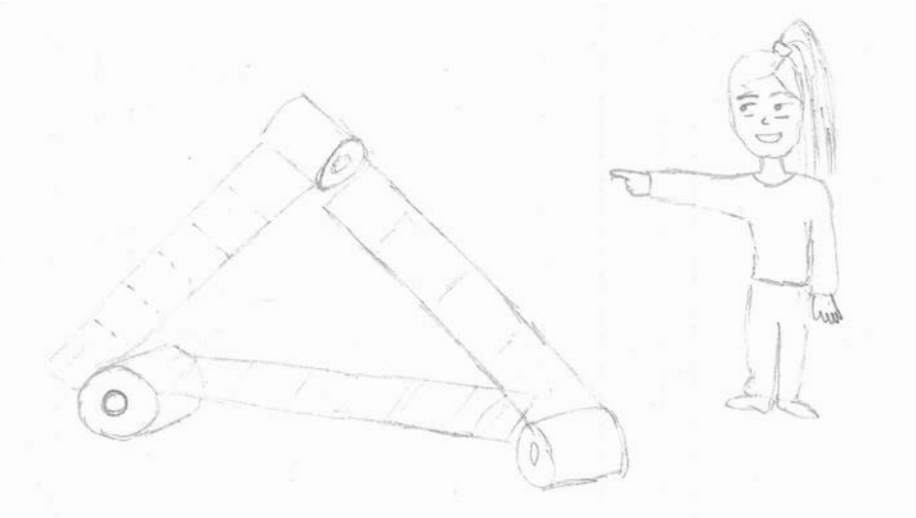

Figure 6. Drawing by Student 'J' (female). Category: teacher - positive

The first one is the case of student 'J'. In her drawing (Figure 6), she is pointing to a triangle formed with toilet paper rolls. She mentioned that her mathematics teacher taught them the Pythagorean theorem using these rolls. She vividly remembers that everyone wanted to participate in the activity, perhaps because of how playful it was. She expresses this enthusiasm in her drawing through a smiling face.

Regarding her image of mathematics in the interview (see below), she pointed out that it is science. When trying to delve deeper into this response, she indicated that it is based on the idea that mathematics is related to science and research, but she did not provide further arguments.

> I: What do you imagine when you hear the word mathematics?
>
> J: Science
>
> I: Where do you think this idea of science comes from?
>
> J: Primarily because it involves numbers and problem-solving, which I believe is mostly related to science, to research, because the theorems required a systematic approach to reach their conclusions.
>
> I: At any point was your perception of mathematics different?
>
> J: Yes, when I was younger, back in primary education, it was quite different than it is now in secondary education. The approach changes a lot because, in primary education, it's very simple, but as time passes, it becomes more complicated.

She mentioned that "the theorems required a systematic approach to reach their conclusions," possibly implying that science is used to derive these mathematical conclusions, such as theorems. However, it is uncertain if she was specifically referring to the Pythagorean theorem. It remains

unclear whether she considers the Pythagorean theorem as part of science, and if this moment was crucial in her change of thinking.

Despite everything, it is interesting that her view of mathematics is broad enough to relate it to science. Perhaps it was something her teacher mentioned that impacted her way of thinking.

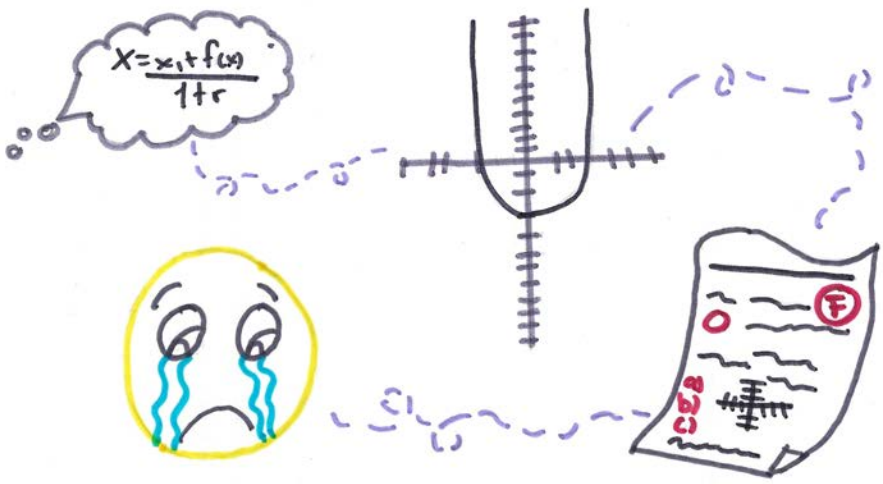

Figure 7. Drawing by Student ‘L’ (female). Category: subject – negative

The final case involves student 'L'. Her drawing (Figure 7) portrays an experience with an analytic geometry exam, prominently featuring elements of this subject, notably the cartesian plane, alongside a visage expressing sadness and tears. In her narrative, she recounts that she started to find mathematics challenging in this subject, and upon failing the exam, she spent her time in tears.

For student ‘L’, mathematics is primarily seen as operations and problem-solving, as evidenced in the interview excerpt provided below.

> I: What do you imagine when you hear the word mathematics?
>
> L: Well, operations, problems, I mean mathematical, and sometimes also life problems because sometimes in life you say, "Oh, I need math," so numbers, signs.
>
> I: Where do you think this perception you have about operations, etc. specifically comes from?
>
> L: I believe it comes from the journey within school where you learn and they tell you, “This might be useful for you in the future," and they teach you about addition, subtraction, division, and you start seeing that it does indeed help you in your daily life. I feel that's how it is. Then it gets more complicated, and you think, "Oh, this doesn't seem useful," or there comes a point where you get frustrated and say, "How is this going to help me?" Maybe later you realize, "Oh, this did help me," or "I can apply it now."

I: Do you think there is a relationship between this perspective you've mentioned about mathematics and the experience you went through?

L: Yes, because it was when it started to get complicated for me, so I feel like I tried very hard, but I didn't achieve it. From there, sometimes I feel like I understand it in class, and I think, "Oh, yes, it's easy," but when they give me the exercises, I think, "Why can't I remember, why can't I do this?"

She indicates that this perception originates from her experiences in school. Although the exam clearly entails mathematical operations, she relates this perception more to her overall school experience rather than specifically to the exam moment. Nevertheless, she points out that this particular moment was critical, marking a turning point where mathematics began to pose greater challenges for her. This could be explained by her feeling that at some stage, mathematical concepts seemed disconnected from real-life utility, reducing mathematics to mere operations.

The image of mathematics by student F, related to arithmetic operations, is a common perspective among Mexican secondary school students (García-González, et al., 2023). Perhaps this is attributed to the teaching methods employed in current classes, where students usually work independently, focusing on routine arithmetic or algebraic operations that have only one correct solution (Hatisaru, 2020a; Turgut & Turgut, 2020).

Moreover, the students' perception of mathematics, particularly regarding operations, can be observed in other related studies (Hatisaru, 2020b; Lim & Ernest, 2000; Turgut & Turgut, 2020).

CONCLUSIONS AND SUGGESTIONS

As we mentioned in introduction, the main objective of the present study is to explore the mental images and significant past experiences related to mathematics among high school students. In this sense, we consider that our goal was achieved, since it allowed us to explore the mental images of the students in relation to their past experiences.

By analysing the drawings made by the students, the first research question, i.e., "What are the past experiences of secondary education students related to mathematics?" could be satisfactorily answered. Subsequently, to address the second question, "What is their current image of mathematics?", the responses provided in the initial interview questions were examined. Finally, the third question, "Does a relationship exist between significant experience and the current image of mathematics?", was successfully addressed by establishing the connection between past mathematics experiences and the current perception held by high school students regarding mathematics.

The results of this study on the image of mathematics are summarized as follows: four students described it as "operations." Additionally, terms like "numbers," "problem solving," and "challenging" were each mentioned at different times by three distinct participants. Finally, two students perceive it as a "mental effort." These were the most frequently mentioned results.

The two highlighted events that have had a significant impact on the formation of the perception of mathematics share a fundamental characteristic: both are experiences that extended over time. The period of the pandemic, for example, had an effect that lasted for months and even years. On the other hand, the influence of parents is constant, as the student points out. This constancy contrasts with the other three experiences, which occurred at specific and concrete moments.

Another observation that could be useful for future studies is that students who have a closer connection to the workplace or who perceive the utility of mathematics in their daily lives tend to appreciate them more. Interestingly, in this study, these experiences were perceived positively by students.

It is noticeable that men are less expressive, both in their drawing and in storytelling, marking a conspicuous disparity with women, who are more notably involved. It is plausible that this drawing tool is more effective in women than in men; however, more thorough research would be needed to explore more deeply into this aspect.

School plays a crucial role in shaping students' perception of mathematics. Defining the desired image becomes crucial considering responses that predominantly centre around numbers and operations, as noted earlier. Thus, the question arises: Where should the redirection of perception be aimed? And, more importantly, how do we achieve this change? These are crucial questions that a teacher might consider before starting a new teaching cycle.

Finally, the usefulness of both drawings and the inquiry into past experiences is emphasised. Students do not feel the pressure of being evaluated based on their drawings, allowing them to express themselves freely without the need to copy. Additionally, exploring their experiences is relevant for several reasons: firstly, it sensitises readers and raises awareness about the role parents and teachers play. Secondly, it provides a path to better understand the origin of the image that students have about mathematics.

LIMITATIONS OF THE STUDY

As a qualitative study, subjectivity is an integral part, necessitating careful consideration of the scope of interpretations (Löfström et al., 2015). Additionally, it is crucial to note that this study is centred around specific cases, precluding generalisation.

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APPENDIX. My past with mathematics

First, brainstorm memories related to mathematics that have had an impact on you, whether positive or negative. These could be events within or outside of school.

Draw the event that had the most significant impact on your life, remembering that it can be either positive or negative.

Now, narrate the story of what you depicted in your drawing.