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Exploring the relationship of prospective primary teachers with mathematics and statistics: memories, emotions and turning points

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Abstract: This study explores the relationship between prospective primary teachers and mathematics. Data was collected from prospective primary teachers enrolled in an undergraduate program. The excerpts have been analysed through Grounded Theory. From the analysis conducted, participants' self-concept regarding the subject, the influence of academic performance and the teacher, and the utility of mathematics in everyday life have emerged as relevant codes. The study identifies turning moments in the participants' educational journeys, generated by the extrinsic factors, which influence the intrinsic ones. Finally, particular attention is given to probability and statistics.

Keywords: affective domain, mathematics, prospective teachers, statistics

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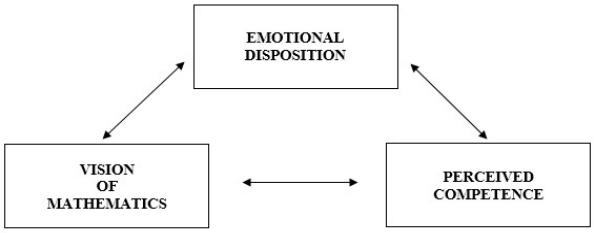
1 Introduction

The purpose of this study is to investigate the affective domain of Prospective Teachers (PTs), as it is a relevant aspect in their future profession (Di Martino & Zan, 2011; Grootenboer & Marshman, 2016; Zan & Di Martino, 2007). Through a qualitative investigation, the present study analyses on the PTs' answers to a questionnaire about their relationship with mathematics, their memories and experiences in mathematics lectures, based on Carotenuto et al. (2022). The objective is to investigate if there are turning moments in the PTs' narratives and from which factors they derive, to identify some types of love-hate relationship with mathematics, to analyse the case of statistics and probability, and to determine if there are patterns in their self-perception, in their strengths and weaknesses in these areas. Furthermore, in greater detail, it aims to delve into their affective domain, derived from their experiences as students.

2 Theoretical background

The emotional dimension is a complex field of study that encompasses several facets; it was described by Pekrun (2006, p. 316) as: "multi-component, coordinated processes of psychological subsystems including affective, cognitive, motivational, expressive, and peripheral physiological processes". The study of the affective domain of mathematics PTs has been a fundamental topic in mathematics education over the last decades (e.g., Goldin et al., 2016). The focus is posed on PTs' beliefs, conceptions, and emotions and their influence on their teaching and, consequently, on students' learning. Some studies even related teachers' knowledge about the affective domain to the mobilized knowledge in the classroom (Aguilar-Mendieta et al., 2021). Di Martino and Zan (2010; 2011) aimed at shedding light on the relationship between beliefs, emotions, and attitudes through the creation of a three-dimensional model for attitude towards mathematics consisting of various affective aspects (Figure 1); for this study, particular attention has been placed on the vision of mathematics and on the emotional disposition, leaving perceived competence out for future works.

Figure 1. Model for Attitude towards mathematics (Di Martino & Zan, 2010, p. 43).



We consider various paradigms of affective domain. Firstly, this study stems from the idea of analysing PTs' answers as in Carotenuto et al. (2022), where PTs' testimonials were analysed to identify the events considered crucial in their educational careers and their relationship with mathematics. One of the main paradigms arising in these experiments is the self-concept. This notion is complex and challenging to be precisely defined, as it possesses multiple facets, and it has a bidirectional relationship with academic achievement (Scheirer & Kraut, 1979), and models as the reciprocal effects (Marsh & Scalas, 2011) propose a dynamic relationship between both. Gómez-Chacón (2000) pointed out that self-concept as mathematics learners is one of the most influential variables in mathematics teaching and learning; it is closely tied to students' attitudes and perspective on the world of mathematics. According to Di Martino and Zan (2011), beliefs concerning self-concept play a central role within people's belief system and have a strong emotional component. Another fundamental aspect in mathematics learning is the influence of teachers. Blanco Nieto et al. (2010) emphasized the importance of having a good relationship with the teacher to enhance mathematics learning. Also, in Carotenuto et al. (2022), one of the prevalent results that emerges from the testimonials of PTs is the influence of the teachers.

As expressed in Di Martino and Zan's three-dimensional model, students' vision of mathematics, including its perceived utility, is an important part of the overall affective domain towards the subject itself. Particularly, this becomes relevant in the case of probability and statistics, as it appears to be easier to relate them to everyday life situations compared to other areas of mathematics (Estrada et al., 2018; Muñiz-Rodríguez & Rodríguez-Muñiz, 2021). Finally, attention can be drawn to the conceptions of mathematics teaching held by PTs, which are complex and sometimes contradictory (Cooney, 1985). Recent research by Panero et al. (2023) and Rodríguez-Muñiz et al. (2022) show that constructivist-oriented tendencies are present in primary PTs, despite there is no sharp profiles in the dichotomy transmission-discovery.

3 Methodology

The study participants were PTs enrolled in the bachelor's degree program for teacher training at the University of Oviedo, where there are three mathematics courses offered in different years: the first one focuses on number and measurement, the second one on geometry, and the third one on probability, statistics, and problem solving. They were asked to complete an anonymous questionnaire during the 2022/23 academic year, at the beginning of this latter course, which is why there is a specific interest in the questions related to probability and statistics, especially considering that it is one of the less developed topics in compulsory education (Muñiz-Rodriguez et al., 2020). The questionnaire consisted of the following demands:

1. How would you describe your relationship with mathematics (specifically statistics and probability) as a student? Would you say it is good or bad?
2. What memories do you have from your school and high school days? Did you enjoy mathematics classes? Or did you hate them? Was it a neutral relationship? Did you study statistics and probability in elementary or secondary school?
3. Was there a turning point in that relationship? If so, what motivated it?
4. How do you rate yourself in statistics and probability? What are your strengths and weaknesses in statistics and probability?

The questionnaire was conducted in Spanish at the beginning of the course (September 2022), and it was translated by the authors for the purpose of writing this paper. The PTs who participated in completing the questionnaire were a total of 91; out of these, 43 responses were selected, resulting in a total of 66 excerpts (in some cases, there were multiple significant parts within the same response). The testimonies that were not selected for this study were very brief and devoid of significant aspects in terms of meaning or content. The methodology used to carry out the analysis is the Grounded Theory (Glaser & Strauss, 1967), an inductive method that uses data to develop theories, hypotheses, and concepts. In this study, following the collection of PTs' responses, a triangulation analysis was carried out by the authors, whereby the most interesting excerpts were described and coded, and the relationships among the codes were analysed.

4 Results

The following codes emerged: the self-concept possessed by the learner (32% of the total excerpts exhibit it), the academic achievement (27%), the conception of the usefulness of mathematics reflected in everyday life (12%) and the influence of the teacher and their teaching methodology (29%).

4.1 Self-concept

As previously mentioned, self-concept is an aspect of an individual's identity that influences the way in which he/she approaches the learning of mathematics. Among the analysed excerpts, twenty-one comments emerged regarding the PTs' self-perception in relation to mathematics.

> PT75: The relationship was a bit of a love-hate one, as when the school year began and I saw myself struggling with it again, I would think, 'Here we go again, the same old story'

It is interesting to highlight how the love-hate attitude towards mathematics coincide with those in Carotenuto et al. (2022).

Another aspect was the comparison with other students:

> PT11: Sometimes, I consider myself slow because I don't come up with as many things as I hear from my classmates, and it frustrates me a lot.

From multiple excerpts, it was evident that PTs' self-concept is determined by their interest in mathematics (particularly, statistics and probability). An example is as follows:

> PT12: I believe that [statistics and probability] is a part of mathematics that I'm quite good at, at least compared to others like geometry or functions. I enjoy it more, and I'm aware that when you like a subject and your interest is higher, the effort you put into learning is also much greater, and therefore, you achieve better results.

There were several excerpts in which PTs immediately highlighted their inadequacy in mathematics, comparing it to humanities subjects, for example:

> PT56: Before discussing my experience with mathematics, I would like to clarify that I have always been more inclined towards the humanities than the social sciences. Therefore, I was not an expert in mathematics nor did I excel in the subject.

4.2 Academic achievement

From the analysed excerpts of the PTs, it emerged how significant academic achievement was in the classroom learning process and how it influenced the participants' relationship with mathematics.

In many excerpts where academic performance was referenced, it was considered by PTs as the reason for the generation of strong emotions in them, often negative ones such as frustration or fear.

> PT15: During secondary school, I felt frustration at not being able to pass all the exams.
> PT17: I remember that when the time came to find out the grades, we would get very nervous. It created an atmosphere of high tension and even fear, as the teacher was very strict.

There were some cases in which the emotions generated by academic results were positive for PTs, such as in the following instances:

> PT18: In most cases, I wouldn't score below a 7 on exams, and in the final grades, I always had either a good or an excellent mark. So, naturally, I was happy with them.
> PT28: I achieved a 6 in the final grade, which boosted my self-confidence.

In few excerpts both positive and negative emotions derived from academic achievements:

> PT59: My relationship with mathematics hasn't been good because I felt frustrated, demotivated, among other adjectives… because I couldn't achieve the results I wanted despite the great effort and dedication I put into them. However, my results and motivation increased when I almost got an excellent grade in the university entrance exam (PAU).

In some cases, PTs mentioned the grades received in class as a source of demotivation towards the study of the subject.

> PT67: Personally, I like mathematics, but since I didn't usually get good grades, it used to demotivate me quite a bit.

There were excerpts, instead, where academic results were mentioned because of the level of interest in the subject.

> PT53: However, in 11th and 12th grades, I started liking them again because I was studying applied mathematics for social sciences. I understood better what needed to be done, and I began getting better grades.
> PT12: I believe that statistics and probability are subjects that I do quite well in, at least compared to others like geometry or functions. I enjoy it more,

> and I am aware that when you like a subject and your interest is greater, the effort you put into learning is also much greater, and therefore you achieve better results.

In this last excerpt, it is worth highlighting that the PT was specifically talking about probability and statistics in a positive way. In particular, it was emphasized how it was precisely thanks to this specific part of mathematics that the interest was greater, and therefore, this influence also affected academic achievement.

4.3 Usefulness of mathematics

Affirmative emotional states were positively associated with the judgment of the usefulness of mathematics in different excerpts, such as:

> PT51: I hated mathematics during the first three years of middle school because I had a very bad teacher.

However, there were also excerpts with a positive connotation (there were excerpts in this code share both positive and negative aspects):

> PT02: It is also true that (…) I had very good teachers who made the subject enjoyable.

Additionally, we identified some excerpts in which PTs referred to teachers' didactic approaches, as in the following case:

> PT35: Regarding mathematics classes themselves, I consider that my performance varied depending on the methodology proposed by the teacher. When the teaching staff chose to focus classes solely on the completion and reproduction of exercises, my reasoning or comprehension was null. In this way, the students reproduced what the teacher exposed despite not understanding the cause or meaning; in that case, my attention and interest were greatly reduced.

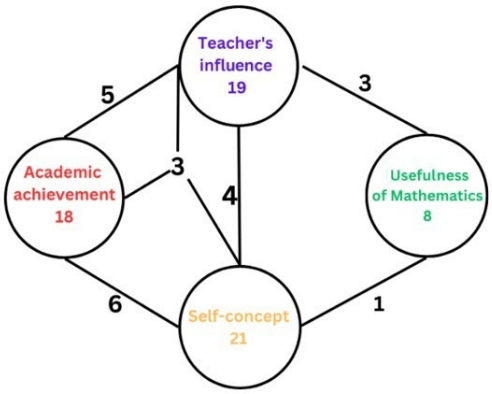
Many PTs instead highlighted experiences connected to the way in which they were treated as students, causing them frustration or anxiety. This was particularly linked to negative comparison with other students:

> PT09: In secondary school […] I felt frustrated for not being able to pass all the exams, and the teacher put a lot of pressure on those who did not achieve good results.

5 Discussion

The categories that can be identified from the analysis are intrinsic and extrinsic factors. Specifically, the self-concept and the usefulness of mathematics fall under the first category, as both aspects closely relate to the participant. On the other hand, among the extrinsic factors, we can include the teacher's influence as an external figure delivering the lesson, and academic achievement, understood as the grade or evaluation given to the individual. In general, as depicted in Figure 2, it is possible to observe how many of the identified codes intertwine with each other, as in most of the excerpts, two or more codes emerge simultaneously.

Figure 2. Graphic representation of the obtained categories. Own elaboration.



Returning to the objectives we set at the beginning, it is interesting to note, firstly, the numerous aspects that are in line with the findings already identified in Carotenuto et al. (2022). The love-hate relationship with mathematics, as highlighted, is a factor that emerges in various excerpts, and in general, the numerous strong and negative emotions that arise stem from the influence of the teacher, as indicated by Carotenuto et al.'s study (2022), but also, in this case, from academic achievement. These factors can lead to a change in their perception of themselves in relation to mathematics, such as the self-concept; it is possible that a *turning moment* occurs in such cases. In this sense, it is possible to relate the two identified categories of intrinsic and extrinsic factors to the previously described interpretive framework: the extrinsic factors in numerous excerpts lead to a significant change in the intrinsic factors. Also, this result is in line with the study conducted by Carotenuto et al. (2022), where participants were mathematics university students, and despite describing problematic situations with the subject matter, they were ultimately experienced as a challenge. In the study by Coppola et al. (2015), on the other hand, participants were preservice primary teachers, and the results of this research indicate that, in most cases, this has generated negative emotions towards mathematics.

One aspect that can be highlighted because of this research concerns the awareness of the participating PTs regarding the significant influence of the chosen teaching method. In fact, many excerpts specified that what students felt lacking was the use of

more hands-on activities rather than traditional methods. In this regard, it is interesting to note that the first two years of university, preceding the moment when they were surveyed, likely influenced their teaching perspective in favour of constructivist-oriented teaching practices (Panero et al., 2023; Rodríguez-Muñiz et al., 2022).

An aspect worth highlighting is the concept of the vision of mathematics (Di Martino & Zan's, 2010). Specifically focusing on the code related to the utility of mathematics, it is noticeable that in many extracts, PTs emphasize that interest in mathematics often arises when its practical utility in everyday life can be seen. Returning to the initial objectives, it is intriguing how PTs frequently highlighted a positive attitude towards probability and statistics due to their concrete and visible aspects in daily life, which makes them more appealing. Another aspect of the vision of mathematics that was positively regarded by some PTs was the act of problem-solving, which was considered as something practical and less associated with theoretical and static study (Rodríguez-Muñiz et al., 2022).

Finally, we acknowledge the limitations of this study. Firstly, the sample of participants selected for this analysis is not random, therefore the results cannot be generalized to students from other universities, even though the obtained results do not deviate significantly from other conducted studies, such as Carotenuto et al. (2022). Another aspect concerns the first question in the instrument, as it specifically asked whether students' relationship with mathematics was good or bad, which could force to position them in a situation that they may not have initially attributed to it, and they may have instead focused on the intensity of the emotions experienced. Furthermore, the coding process may have subjective connotations as it was carried out by the authors themselves, who are affiliated with the university. Lastly, the data was collected at the beginning of the Probability and Statistics course, which implies that participants may not attribute the appropriate relevance to the subject, considering that, in many cases, it is not studied in secondary education (Muñiz-Rodriguez et al., 2020). Therefore, it would be interesting to conduct further studies that follow the same research approach, possibly, also developing aspects such as teacher's self-efficacy, identity and concept of mathematical views, with the hope of overcoming these limitations and thus being able to draw even more comprehensive conclusions.

Research ethics

Author contributions

G.C.: conceptualization, data curation, formal analysis, investigation, methodology, validation, visualization, writing-original draft, writing-review & editing.

A.A.G: formal analysis, funding acquisition, methodology, supervision, validation, writing-review & editing.

L.J.R.M.: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, supervision, validation, writing-review & editing.

All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest

The authors declare no conflicts of interest.

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