TRACING PRE-SERVICE PRIMARY TEACHERS' VIEW OF MATHEMATICS THROUGH RETROSPECTIVE GRAPHS

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Pre-service primary teachers' (PSTs) views of mathematics play a central role in them becoming effective mathematics teachers. As these views are constructed through prior experiences, understanding how such experiences are formed is essential to support the development of more positive views of mathematics. The data consists of 101 PSTs' retrospective graphs representing their relationship with mathematics and its variation over time. The analysis revealed five graph-shape categories, Positives, Uphills, Negatives, Downhills, and Zigzags, with aspects such as motivation, competence, perceived difficulty, effort, and former teachers associated with changes along the way. Overall, the study demonstrates that graphs offer a valuable alternative for solely verbal and written responses.

INTRODUCTION

Pre-service primary teachers (PSTs) enter teacher education programmes, and later their own classrooms, carrying their mathematics-related views constructed through previous experiences with mathematics (Bekdemir, 2010; Guillaume & Kirtman, 2010; Kim et al., 2023). These experiences originate largely from PSTs own schooling, and views of mathematics constructed through these experiences tend to influence their future instructional practices, classroom environments, and ultimately their students' learning and views of mathematics (Kim et al., 2023). Therefore, when aiming for high-quality mathematics teaching and learning, teacher education programmes play a central role in reshaping PSTs' views of mathematics.

The term "view of mathematics" is seen to encompass a range of cognitive as well as affective and motivational dimensions, such as beliefs, attitudes, emotions, and self-related constructs (Kim et al., 2023). Similar to Roesken et al. (2011), these dimensions are understood to be formed and developed through individuals' previous experiences of learning mathematics. Previous research has investigated the mathematics-related experiences PSTs bring with them to teacher education programmes. These experiences include for example experiences of success or failure while learning mathematics, perception of own competence and ability to learn mathematics, perceived difficulty of mathematical content, levels of enjoyment, motivation, and effort, as well as parental and peer encouragement or pressure (Bekdemir, 2010; Guillaume & Kirtman, 2010; Hannula et al., 2005; Roesken et al., 2011).

It is important that PSTs have or develop a positive view of mathematics. Firstly, experiences with teachers have a crucial role in shaping students' views of

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mathematics; research shows that both positive and negative experiences with mathematics are often teacher-related (Bekdemir, 2010; Guillaume & Kirtman, 2010; Hannula et al., 2005; Lo, 2021). In this vein, the goal is to educate teachers who can provide their students with positive experiences with mathematics. Secondly, PSTs need a positive view of mathematics to benefit from teacher education (Brady & Bowd, 2005; Erixon & Christiansen, 2025). For example, positive views of mathematics help PSTs in learning to teach mathematics more effectively (Lo, 2021). In contrast, a negative view of mathematics can result in negative experiences within teacher education programmes (Bekdemir, 2010). This may lead PSTs to avoid more effective teaching practices (Brady & Bowd, 2005), again reducing their future students' possibilities for positive mathematics learning experiences.

However, it is important to note that not all negative previous experiences have negative consequences. For example, PSTs' negative experiences with mathematics can hinder their teaching efficacy, but the same can also motivate them to learn to teach mathematics better for their students (Guillaume & Kirtman, 2010; Lo, 2021; Rule & Harrell, 2006). Furthermore, sometimes a teacher's own negative experiences can serve as key to understanding students better; teachers with only positive experiences with mathematics can find it challenging to relate to students facing difficulties in learning mathematics (Lutovac & Havia, 2024). Hence, PSTs can use their negative experiences to become more effective mathematics teachers.

Still, in order to support the development of more positive views of mathematics, and to help PSTs use their negative experiences to create positive outcomes during teacher education, there is a need to understand the previous experiences through which PSTs constructed their views of mathematics. To address this, the present study investigates PSTs retrospective graphs representing their relationship with mathematics from the first grade up to the point of the beginning of the first mathematics didactics course at university. Asking PSTs to write or talk about their views of mathematics may not result in well-articulated responses, highlighting the need for alternative methods (Erixon & Christiansen, 2025). In addition, cross-sectional studies overlook developmental perspectives. Here, the use of retrospective graphs provides a novel way for PSTs to express their experiences and illustrate how and why their relationship with mathematics changes over time (Satyam et al., 2022). The research questions are:

1. What kind of relationship do PSTs have with mathematics from the first grade up to their first mathematics didactics course in the teacher education programme?
2. To what factors do PSTs attribute changes to in their relationship with mathematics over time?

In addition, the study has a pedagogical development dimension. Reflecting on previous experiences with mathematics through drawing activities can increase PSTs' awareness of these experiences and support the development of a more positive view

of mathematics (Guillaume & Kirtman, 2010; Rule & Harrell, 2006; Satyam et al., 2022). Thus, the study also serves as an intervention for the PSTs

METHODS

The study involved 101 PSTs who attended the first small-group session of their first mathematics didactics course in their teacher education programme in Spring 2025. The participants gave active consent to participate in the research, and the response rate was 86 percent. Similar to Satyam et al. (2022) and Andrà and Scalvini (2023), the data were collected via minimally structured graphs. Graphing provides autonomy for PSTs to express their experiences (Satyam et al., 2022) and gives them a tool for making their experiences concrete. The PSTs were asked to sketch graphs representing their relationship with mathematics. The vertical axis (relationship with mathematics) had three marks, positive, neutral, and negative, and the horizontal axis (time) was unstructured. The students were prompted with the following task:

- Draw a line on the graph that represents your relationship with mathematics from the beginning of first grade up to this moment.
- Explain what happens in the graph. Focus on points where changes occur. Indicate the time of the change (e.g., 4th grade) and write what happened then.

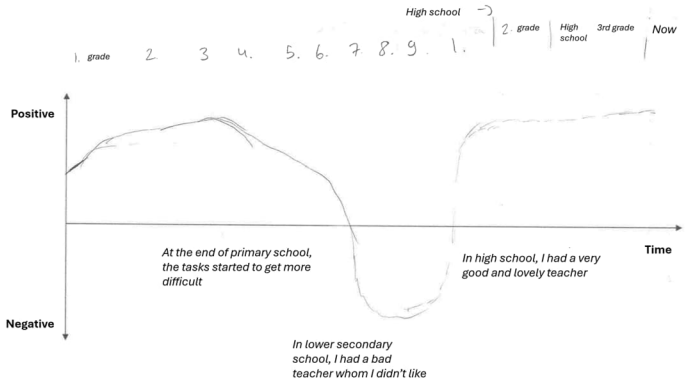
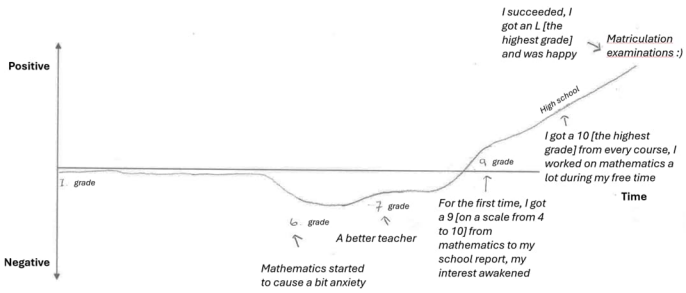
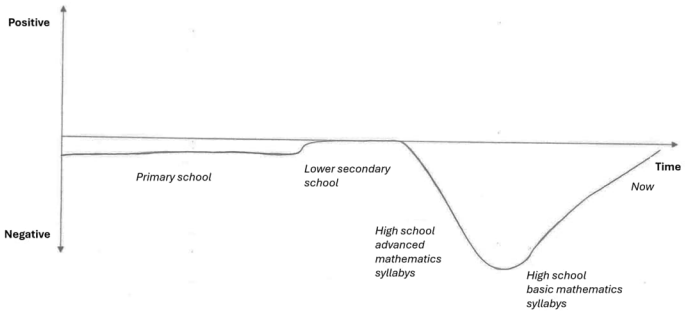
The data were analysed using data-driven qualitative content analysis (Schreier, 2012). First, the graphs were analysed by examining trends over time, that is, by comparing the valence and relative magnitude of the start and end points, and by analysing their overall shape and temporal ordering. These aspects were used inductively to build the coding frame, and the graphs were then grouped by shape into qualitative categories in an iterative fashion (see Table 1). The analysis then continued with in vivo and descriptive coding (Saldaña, 2021) of the PSTs' own words associated with changes in their graph shapes. The resulting codes were organised into broader descriptive categories that reflected recurring themes across the data. Finally, these categories were examined separately for peaks and valleys to identify the common aspects associated with positive and negative shifts in the PSTs' relationship with mathematics.

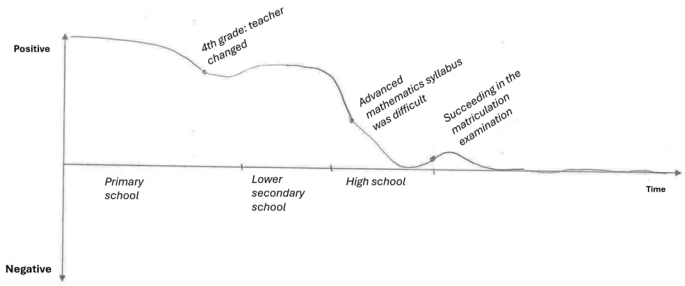
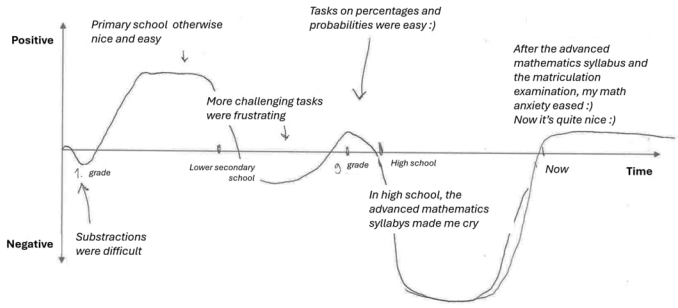
RESULTS

When comparing the valence of the start and end points, the PSTs' graphs show that 75 percent of the students started in first grade with a positive relationship with mathematics. In addition, 16 percent started with a neutral, and 9 percent with a negative relationship with mathematics. At the end, that is, upon entering the first mathematics didactics course in their teacher education programme, 67 percent of the students reported having a positive, nine percent a neutral, and 24 percent a negative relationship with mathematics. Over the course of their school years, 17 percent increased their valence, 29 percent decreased their valence, and 54 percent had the same valence (positive, negative, or neutral) both at the start and end points.

Based on the valence, the overall shape, and temporal ordering of the graphs, five qualitative graph categories representing the PSTs experiences with mathematics were identified: Positives, Uphills, Negatives, Downhills, and Zigzags. The categories are presented in Table 1. Four of the categories are somewhat equally represented; however, there are only two graphs in the Negatives category implying that only two students reported having a solely negative relationship with mathematics during their school years.

Table 1. The five categories representing the PSTs views of mathematics formed through their previous experiences with mathematics.

Category	Definition	Example
Positives (n=31)	The dominant feature is positivity. Graphs start and end on the positive side at roughly the same level, Peaks and valleys may occur along the way, crossing also into the negative side.	
Uphills (n=26)	The dominant feature is an uphill. Graphs may start negative, neutral, or positive but always end on the positive side. Peaks and valleys may occur along the way but the overall trend is still upward.	
Negatives (n=2)	The dominant feature is negativity. Graphs start and end on the negative side roughly at the same level. Peaks and valleys may occur along the way, not crossing into the positive side.	

Downhills (n=19)	The dominant feature is a downhill. Graphs typically begin on the positive and end on the negative side. Peaks and valleys may occur along the way, but the overall trend is still downward.	
Zigzags (n=23)	The dominant feature is variability. The graphs alternate between positive and negative values, with multiple peaks and valleys without a clear overall trend.	

The PSTs linked various factors to changes in their relationship with mathematics over time. Positive shifts were associated with personal interest and motivation, liking mathematics, and seeing it as important. Experiences of success and competence were central, also reflected in good grades and success in the matriculation examination at the end of high school. Positive changes also occurred when PSTs consciously reduced the level or amount of mathematics studied, for example by switching from the advanced to the basic mathematics syllabus in high school and, in this way, making the mathematical content less challenging. Teachers and teaching were likewise central, as nice, supportive teachers and effective teaching were linked to positive changes. In addition, the PSTs' own teaching-related experiences such as work in teaching roles and orientation towards a teaching career were associated with positive changes in their relationship with mathematics.

Negative changes in PSTs' relationships with mathematics were linked to lack of interest and motivation, weak self-confidence and frequent experiences of incompetence. Lower effort, whether due to limited time or energy, or feeling unable to meet expectations, also contributed to declines in the PSTs relationship with mathematics. Many PSTs reported increasing difficulty with certain topics or tasks, and following the advanced mathematics syllabus in high school was mostly associated with a negative shift. Teachers and teaching practices played a notable role as well; Several PSTs recalled former teachers they perceived as ineffective, and some reported experiences of humiliation or shaming, all of which were connected to negative shifts in their relationship with mathematics.

DISCUSSION

The present study investigated PSTs' retrospective, minimally structured graphs to explore the development of their views of mathematics over time (see Andra & Scalvini, 2023; Satyam et al., 2022). As views of mathematics are constructed through previous experiences (Roesken et al., 2011), the PSTs were asked to graph their relationship with mathematics from the first grade up to the beginning of the mathematics didactics studies. As expected, the analysis revealed substantial variation in the graphs including positive, neutral, and negative experiences, as well as fluctuations (peaks and valleys) across school years (Guillaume & Kirtman, 2010).

The main contribution of the study concerns the use of retrospective graphs as a data collection method. Five graph-shape categories were identified: Positives, Uphills, Negatives, Downhills, and Zigzags. These shape patterns highlight the diversity of the PSTs' previous experiences. Notably, only two PSTs described an entirely negative relationship with mathematics across the school years; the remaining 99 participants reported at least some positive experiences. This distinction is meaningful; PSTs who currently hold a negative view but have encountered positive experiences along the way differ fundamentally from those with solely negative experiences with mathematics. Similarly, PSTs whose relationship has remained positive throughout are distinct from those who currently feel positive but have struggled in earlier phases. Overall, using retrospective graphs highlight the notion that it is not only the present moment that matters (or the time of cross-sectional data collection) but all experiences that construct a view of mathematics.

Another main finding is the prevalence of positive views of mathematics at the beginning of teacher education. Two thirds of the PSTs reported a positive relationship with mathematics, a considerably higher proportion than that found among Finnish PSTs twenty years ago (43%; Hannula et al., 2005). At the same time, the proportion with negative views, about one quarter, has remained relatively stable. The present study also identified only nine percent of neutral views, compared with 36% in Hannula et al. (2005). One possible explanation for this is methodological. Hannula et al. (2005) used a quantitative approach that allowed more fine-grained analysis of neutral views of mathematics, whereas retrospective graphs may emphasise the developmental process more strongly. It is also possible that PSTs, when reflecting visually on their view of mathematics, become more aware of fluctuations and the positive and negative sides of the axes and thus represent their experiences with more nuance than cross-sectional surveys typically capture.

The findings further demonstrate that PSTs can enter teacher education with a positive view of mathematics despite having encountered significant negative experiences earlier in their school years. Negative experiences do not determine view of mathematics long term. In fact, they may offer pedagogical advantages, as PSTs with a history of struggle can be better at relating to students who find mathematics difficult (Lutovac & Havia, 2024). This reinforces the idea that teacher education should not

aim to eliminate negative experiences but should help PSTs reinterpret and reuse them. The graphs also showed considerable contextual variation, suggesting that the PSTs' views of mathematics are sensitive to contextual and instructional factors. This indicates that teacher education has a meaningful opportunity to provide more positive experiences and, in this way, strengthen the PSTs' views of mathematics with which they then enter the teaching profession (Bekdemir, 2010; Guillaume & Kirtman, 2010; Kim et al., 2023).

The factors PSTs associated with positive and negative changes align closely with prior research (see Bekdemir, 2010; Guillaume & Kirtman, 2010; Hannula et al., 2005; Roesken et al., 2011). Positive changes were connected with motivation, interest, experiences of success and competence, suitable level of challenge, supportive teachers, and meaningful teaching-related experiences. Negative changes were linked to low motivation, weak self-confidence, perceived incompetence, increasing difficulty of mathematical content, insufficient effort or lack of time, and poor or even harmful teachers and teaching practices. The finding that some PSTs had improved their relationship with mathematics by switching from the advanced to the basic syllabus in high school raises an important point. Teachers do not have the option to "lower the level" of mathematics in their work. This highlights the need in teacher education to find other ways to strengthen the PSTs views of mathematics. As the PSTs associated meaningful teaching-related experiences with positive shifts in their views of mathematics, strengthening connections between theory and practice and providing supportive guidance and feedback during teaching practicums can strengthen PSTs' views of mathematics and in this way, support their development as effective mathematics teachers.

Limitations and future research

This study has several limitations. First, retrospective graphs are subjective representations of PSTs' relationships with mathematics (Satyam et al., 2022). Therefore, the findings are limited to the experiences the PSTs prioritised and remembered. Also, PSTs may refer for example to "good" teachers differently (Guillaume & Kirtman, 2010; Lo, 2021). Second, because the axes are not standardised, the graphs are not suitable for between-subject comparisons regarding the absolute level of positive or negative experiences. They do, however, support meaningful within-subject interpretations such as relative increases, decreases, or turning points

The present study is a part of a larger research project in which the PSTs continued to draw graphs throughout the mathematics didactics course. Future research will combine these data to examine how previous experiences are linked to experiences during teacher education programmes. Also, triangulation for example via mini-interviews could prove helpful in understanding the developmental process of PSTs' views of mathematics in greater detail (see Satyam et al., 2021).

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