

Facilitators, Indicators and Consequences of Engagement in Learning Mathematics in the Written Memories of Preservice Primary School Teachers

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☞ The present paper explores engagement in mathematics learning in order to identify factors that facilitate engagement. Given their future teaching responsibilities, the target group was preservice primary school teachers. Fifty-eight Hungarian preservice primary school teachers reported their favourite experience related to learning mathematics from school life before university. A content analysis of the written recollections was conducted, focusing on facilitators (mathematics, environment, self, peers, teacher), indicators (behavioural, emotional and cognitive) and consequences (academic success) of engagement. The method proved to be valid based on a satisfactory relatedness between two signs of engagement: the occurrence of different types of indicators in memories and the length of memories counted in words. The students recalled self-related facilitators (such as self-experience and perceived competence) and teacher-related facilitators (such as control) with a high frequency of 31% and 43%, respectively, while mathematics-related facilitators appeared with a lower frequency of 13%. Academic performance was substantially associated with cognitive engagement co-occurring with facilitation from teachers, self and peers. Teacher facilitation was associated with all three types of engagement indicators. The findings suggest that having supportive teachers can enhance engagement even among students who show limited interest in mathematics. The study provides insights into preservice primary school teachers' engagement in mathematics, potentially informing and enhancing teacher education programmes.

Keywords: engagement, learning mathematics, facilitators, written memories, preservice primary teachers

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Spodbujevalni dejavniki, kazalniki in posledice zavzetosti za učenje matematike v pisnih spominih bodočih osnovnošolskih učiteljev

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☞ Ta članek raziskuje zavzetost za učenje matematike z namenom opredelitve dejavnikov, ki spodbujajo zavzetost. Glede na njihove prihodnje pedagoške odgovornosti so bili ciljna skupina bodoči osnovnošolski učitelji. Oseminpetdeset madžarskih bodočih osnovnošolskih učiteljev je opisalo svojo najljubšo izkušnjo, vezano na učenje matematike iz šolskega življenja pred vstopom na fakulteto. Opravljena je bila vsebinska analiza pisnih spominov, ki se je osredinjala na spodbujevalne dejavnike (matematika, okolje, jaz, vrstniki, učitelj), kazalnike (vedenjske, čustvene in kognitivne) in posledice (učni uspeh) zavzetosti. Metoda se je izkazala za veljavno na podlagi zadovoljive povezanosti med dvema znakoma zavzetosti za učenje matematike: pojavom različnih vrst kazalnikov v spominih in dolžino spominov, izmerjeno v besedah. V svojih spominih so študentje navajali spodbujevalne dejavnike, povezane s samimi seboj (kot sta lastna izkušnja in zaznana kompetenca), in spodbujevalne dejavnike, povezane z učiteljem (kot je nadzor), z visoko pogostostjo, tj. 31 % oziroma 43 % za vsako izmed teh kategorij dejavnikov, medtem ko so spodbujevalne dejavnike, povezane z matematiko, navajali z nižjo pogostostjo, tj. 13 %. Učni uspeh je bil v veliki meri povezan s kognitivno zavzetostjo, ki je potekala ob podpori učiteljev, samega študenta/učenca in sošolcev. Podpora učiteljev je bila povezana z vsemi tremi vrstami kazalnikov zavzetosti. Ugotovitve kažejo, da lahko učitelji, ki podpirajo učence, okrepijo zavzetost tudi pri učencih, ki kažejo omejeno zanimanje za matematiko. Študija ponuja vpogled v zavzetost bodočih osnovnošolskih učiteljev za matematiko, kar lahko prispeva k oblikovanju in izboljšanju programov izobraževanja učiteljev.

Ključne besede: zavzetost, učenje matematike, spodbujevalni dejavniki, pisni spomini, bodoči osnovnošolski učitelji

Introduction

Engagement is a complex, motivation-related concept that is widely used in various contexts, including education, work and sports. Its complexity comes from the emotional, cognitive and behavioural facets of the construct (Fredricks et al., 2004). From the perspective of mathematics education, the emotional facet of engagement is closely related to students' attitudes towards mathematics. Following Hannula et al. (2016), we understand attitude as a multidimensional construct that brings together emotional responses to mathematics, views of mathematics and perceived mathematical competence as a learner. Beyond liking a specific subject, being engaged means elaborating many thoughts and ideas related to that special subject and actively devoting a substantial amount of time to it.

In the past few decades, interest in this construct has also grown in the educational context, and most studies have found a positive and significant relationship between school engagement and academic achievement (Martins et al., 2022). Thus, in education, engagement has become central to efficient learning, and researchers study its correlates to understand how students can be more engaged. The present study complements existing research by examining these correlates of engagement in mathematics learning.

Most studies rely on quantitative questionnaires; however, Fredricks and McColskey (2012) highlighted the limitations of such instruments, since questionnaire studies necessarily limit the scope of a phenomenon to the constructs measured. Instead, they advocated for qualitative approaches, including observations and narratives. Hauk (2005) adopted the method of autobiographical writing by asking mathematics students to write about their experiences learning mathematics. Di Martino and Zan (2010) qualitatively studied attitudes towards mathematics through an essay entitled "Me and Maths" written by students from every level of education. They concluded that the relationship appears to be unstable; in other words, it can be influenced in a positive direction.

The present study adopts a narrative perspective, analysing positive memories of mathematics learning recalled by first-year university students. We accept the opinion of Connelly and Clandinin (1990) that "humans are storytelling organisms who, individually and socially, lead storied lives. The study of narrative, therefore, is the study of the ways humans experience the world" (p. 2). Unlike earlier qualitative studies, we imposed minimal constraints: participants were only asked to recall and write about a positive mathematics-related memory.

The study focused on a special sample of preservice primary school teachers who, at least in Hungary, are not required to take a school-leaving exam in mathematics at an advanced level but at a basic level. Presumably, they are not particularly engaged with mathematics. This phenomenon is not unique; for example, Panero et al. (2023) argue that “numerous preservice primary school teachers begin their training with a negative attitude towards mathematics” (p. 467). In a study with Israeli participants, Patkin and Greenstein (2020) identified that even inservice primary school teachers can show mathematics anxiety and mathematics teaching anxiety, especially when they are specialised in the liberal arts rather than mathematics but still have to teach mathematics due to a shortage of specialist mathematics teachers. In Hungary, the situation is comparable: irrespective of whether primary school teachers are involved in mathematics, they are empowered to undertake all teaching responsibilities, including mathematics instruction, for grades 1 to 4. Thus, identifying the correlates of their engagement is important. As revealed in a study by Lutovac and Kaasila (2014), even preservice teachers who recall negative memories of learning mathematics during their school years can shift the way they envision the mathematics-related dimension of their prospective teacher identity (how they interiorise the social role of being a teacher), depending on the nature of the experiences they encountered during the teacher education programme. We assume that the positive experiences preservice teachers recall from their earlier schooling exhibit a certain continuity with the kinds of learning experiences they seek once they enter higher education.

The use of a narrative approach to explore preservice teachers’ experiences related to mathematics teaching thus has an established tradition. In his groundbreaking work, Kaasila (2007) used a narrative approach to analyse experiences as they were lived during teacher education, regarding narrative inquiry as a particularly powerful approach for examining preservice teachers’ experiences of learning and teaching mathematics during teacher education. He argues that educational experience is inherently narrative in form – that learners interpret their past through storied, meaning-making accounts – and that such experiences are therefore best understood through the stories teachers tell about their lives and learning. We assume that the experiences lived during teacher education become woven into, and accumulate alongside, earlier experiences. For this reason, examining the pre-university experiences of prospective primary teachers may also be insightful, not least because it would be desirable for as many primary teacher candidates as possible to enter their studies already open to mathematics and its teaching. In the long term, this can best be achieved if their engagement is fostered already during their secondary

school years, or even earlier, during their primary school years.

Using an idiographic approach allowed us to identify both established and novel elements of mathematical engagement. For example, all of the constituent elements of a recently formulated framework for mathematical engagement, conceived by Roche et al. (2023), were present in our research; however, new elements also emerged, such as articulating a self-regulation motif that invested effort yields results. Additionally, the generally formulated motifs in the article by Roche et al. (2023) were illuminated with important details.

Overall, the present study aims to deepen the understanding of engagement in mathematics learning among preservice primary school teachers and to inform strategies for its enhancement.

Theoretical Background

The Notion of Engagement in the Context of Education

Engagement is a key and rapidly developing area of research in education and educational psychology (Skinner & Raine, 2022). It is an integrative construct encompassing multiple theoretical perspectives as well as the emotional, cognitive and behavioural dimensions of students' educational experiences. Engagement reflects students' connection to school – including social relationships, educational goals and values – and the learning environment and activities.

The conceptualisation of “engagement” has evolved over a considerable period. A noteworthy contribution to the conceptualisation process was the handbook by Christenson et al. (2012), whose proposed definition also guides how we conceptualise engagement in mathematics in the present study:

Student engagement refers to the student's active participation in academic and co-curricular or school-related activities and commitment to educational goals and learning. Engaged students find learning meaningful and are invested in their learning and future. It is a multidimensional construct that consists of behavioural (including academic), cognitive, and affective subtypes. (pp. 816–817)

Reschly and Christenson (2012) added that student engagement encompasses students' thoughts and feelings about learning, their classroom and school, the perceived relevance of education and their relationships with others, as well as the ways they attend, participate and behave in class and at school.

Student engagement is commonly conceptualised as a multidimensional construct encompassing behavioural, emotional and cognitive dimensions. The behavioural dimension refers to participation in learning activities,

the emotional dimension to affective responses to learning, and the cognitive dimension to the use of higher-order thinking skills, such as problem solving (M.-T. Wang & Eccles, 2013; M.-T. Wang et al., 2016).

Students' Engagement in Learning Mathematics

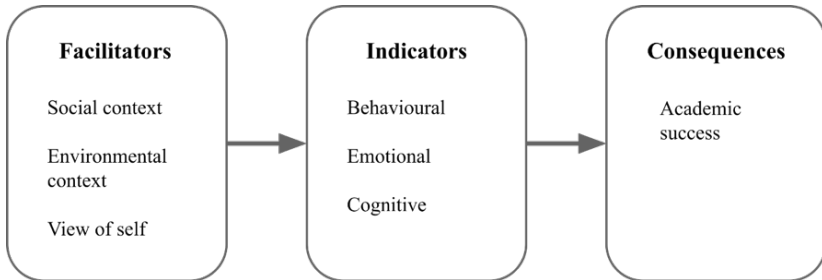
The engagement construct has also found its way into mathematics education, or in a broader context, into STEM education research. The starting point is often the “universal trend of declining mathematical performance” (Durksen et al., 2017, p. 164) or, in other words, the relationship between low-level engagement and academic underachievement (Martin & Marsh, 2006). International assessments, such as TIMSS 2019–2023, show that students' liking of mathematics remains substantially lower at Grade 8 and has shifted unfavourably since 2019 (Mullis et al., 2020; von Davier et al., 2024).

Kong et al. (2003) emphasise the importance of examining learner engagement in mathematics, arguing that understanding learner engagement can inform classroom practice and curriculum design in order to enhance engagement and learning outcomes. They highlight the necessity of a multidimensional approach in order to capture the complexity of engagement, which underpins research seeking factors that promote engagement and achievement. These factors are often called facilitators.

Skinner (2016) developed a model for explaining the relationship between the facilitators, indicators and consequences of engagement in a general educational context, which was subsequently adapted by Roche et al. (2023) to describe engagement in mathematics (see Figure 1). In this adaptation, facilitators come from social relationships (with the leading role of teachers), from the environment (tasks, content, manipulatives) and from the view of self (the experience of self-efficacy). This “view of self” is very similar in its content to what Pehkonen (1995) means by “beliefs on oneself” as a part of the “view of mathematics”, with the content “self-confidence” and “success in mathematics”. These facilitators support the appearance of engagement on the different levels of functioning (behaviour, affect and cognition), which are facets of the multidimensional engagement concept (Christenson et al., 2012; Fredricks et al., 2004; Skinner, 2016). The indicators of behavioural engagement are effort, persistence and focus. Enthusiasm, interest and enjoyment indicate affective engagement, while mastery orientation in the field or developing self-regulatory strategies to improve achievement indicate cognitive engagement. According to the model, engagement has its consequences, manifested in results such as improving learning and academic success, including completing projects or graduating (Figure 1).

Figure 1

The Facilitators-Indicators-Consequences model of engagement, based on Roche et al. (2023)



Although implying a causal order from facilitators via indicators to consequences, the Facilitators-Indicators-Consequences model also allows reverse-directed and mutual connections between the elements. For example, academic success, as a consequence of engagement, can facilitate further engagement.

Mathematics Teachers as Facilitators of Engagement in Learning Mathematics

Teachers are crucial facilitators of student learning (Liu et al., 2018; Patrick et al., 2007; Simons-Morton & Chen, 2009). Recent research has further highlighted how influential the way teachers undertake their roles is on student engagement. Bobis et al. (2020) found that shifts in teachers' mathematics-related identities, particularly as they see themselves as "facilitators", "learners" and "cocreators" of knowledge, can significantly positively affect students' engagement and autonomy in learning mathematics. Such repositioning of teachers can lead to practices that empower students as responsible agents of their learning.

In what follows, we survey selected research that examines teachers as facilitators of engagement. In the study of teaching-method-specific impacts on engagement, the distinguished facilitator is the method itself (Hallifax et al., 2020). Studying different methods allowed by the development of information technology, even in an online environment, is quite widespread, mainly in the higher education context, especially since the start of the pandemic (Muir et al., 2020, 2022).

Research on socioemotional facilitators consistently highlights the importance of teacher support for student engagement in mathematics. Studies across different educational levels show that emotionally supportive teaching is associated with higher cognitive, emotional and social engagement

(Rimm-Kaufman et al., 2015; Roche et al., 2023), including in online learning contexts (Muir et al., 2020). With respect to professionalism, interestingly, teachers' general academic ability seems to contribute less to students' engagement than their specific skills in promoting engagement (Liu et al., 2018). This is in line with observations in a nationally representative sample of 194 German secondary school mathematics classes (Kunter et al., 2013), where teachers' pedagogical competence, enthusiasm for teaching and self-regulatory skills regarding instructional quality – but not academic ability – were correlated with the achievement of students (which can be seen as a consequence of student engagement) and enjoyment of mathematics (as an indicator of affective engagement).

Taken together, these research findings imply that contextual and personal facilitators promote student engagement in mathematics, with teachers playing a particularly important role. For preservice primary teachers, autobiographical memories of engaging mathematics episodes are likely to crystallise these facilitators, indicators and consequences into personally meaningful narratives.

The present study therefore analyses preservice teachers' written recollections of positive mathematics-learning experiences from public education through the lens of the Facilitators-Indicators-Consequences model (Roche et al., 2023; Skinner, 2016) in order to better understand how engagement in mathematics is retrospectively constructed at the outset of their teacher education. Although narrative studies of mathematics learning often rely on essay titles or guiding prompts, we analyse minimally guided, spontaneously written positive memories to show how engagement components are organised in spontaneous, unguided narratives. These novelties – the target population, the object of recollection (experiences in public education) and the method eliciting spontaneous recall of memories – cover a gap in the research on engagement in learning mathematics.

Research Questions

The main research question was how first-year preservice primary school teachers articulate written memories of positive experiences with learning mathematics and how engagement (with its facilitators, indicators and consequences) appears spontaneously in their memories. First-year preservice primary teachers typically enter university with a moderate relationship to mathematics. Understanding the correlates of their engagement at this stage is crucial for their subsequent professional preparation.

It was expected that the recalled episodes would constitute valid manifestations of students' past engagement and reflect the facilitators, indicators and consequences identified in the literature (Roche et al., 2023; Skinner, 2016). Links between these elements were therefore examined, with particular attention to teacher-related facilitators and mathematics-related curriculum content that can be influenced via education policies related to teacher education and curriculum design.

Method

Participants

Fifty-eight first-year, full-time preservice primary school teachers (females = 56; males = 2, with an average age of 19.7) from eight Hungarian universities participated voluntarily in the online study. The research was conducted in 2022, at the beginning of the first semester. The participants represent 19.8% of the population of first-year, full-time preservice primary school teachers taking this major in Hungary in 2022. None of the participants had taken an advanced-level school-leaving exam in mathematics.

Data Collection Instrument

The participants were offered a link to the online prompt at the very beginning of their first semester in university and were asked to participate voluntarily by their university mathematics teachers. They did not complete their responses during a lecture but on their own, whenever and wherever they wanted.

The participants were asked to recall and write down a memorable positive experience with learning mathematics. The instruction was "Please share with us a memorable positive experience with learning mathematics from earlier times, when you attended primary or secondary school. Why did you choose that memory?". We asked for positive memories to avoid deepening the potentially harmful consequences of bad memories. However, five students also recalled bad memories.

Research Design

Based on the literature – mainly the items by Skinner (2016) and Roche et al. (2023) – and adjusting to the information provided by students, a 17-element coding system was established. Table 1 provides the names of the codes and shows examples for each code.

Regarding facilitators, we distinguished between sources of positive stimuli: mathematics (content, positive opinion), school environment, self (perceived

competence, experience of success), peers, and teachers (supporting self-efficacy, helpfulness and support, friendly, empirical learning, control, challenge). The indicators were classified according to the conventional category system of behavioural, cognitive and affective indicators. One code was used for the consequence of engagement (academic success) and a second code was used for unrelated memories (mainly because they were negative instead of positive).

Two of the authors cooperated in segmenting the text in order to split it into segments that could be coded with a single code, while the other two authors coded the text independently. Krippendorff's α was chosen as the reliability measure due to its appropriateness for content analysis (Hayes & Krippendorff, 2007). The computed Krippendorff's α for the study was 0.741, so the intercoder reliability was above the limit of substantial (.7) agreement. Debated codes were resolved through group consensus among the co-authors.

Narrative length, measured as the total number of words, was used as a proxy for emotional engagement. Since the responses to the two prompts were often inseparable, word counts were based on the full text. Prior research shows that emotionally salient memories are reported in greater detail and length (Bohanek et al., 2005; Schaefer & Philippot, 2005); accordingly, narrative length served as a validation target by relating it to the presence of behavioural, emotional and cognitive engagement indicators.

The corpus was organised, annotated, retrieved and analysed with the qualitative data analysis software QDA Miner (Version 6.0., <https://provalisresearch.com>).

Results

The Appearance of Key Content of the Conceptual Framework

The written memories reported both old, primary-school-related memories (11 cases), and recent, secondary-school-related (29 cases) memories, with recent memories predominating. In 18 cases, it was not possible to judge the temporal origin of the memory. The average length of the written memories was 32.81 words ($SD = 22.62$ words). The text corpus was segmented into 206 segments (on average, consisting of 9.27 words).

Table 1 presents the frequency of each code at the individual level, i.e., the number of individuals whose memory contained content falling into the specific code category. At the level of the participant, the most frequent topics were emotional engagement and cognitive engagement, with 22 and 14 respondents mentioning these topics, respectively.

Of the 134 segments describing facilitators, 57 referred to teachers and 41 to the students themselves. Of the six teacher codes, control occurred at least twice as frequently as any other teacher code, with 21 mentions. Thus, the way in which the mathematics teachers organised the classes was the most memorable and noteworthy of the teachers' activities that were recalled as good memories. Regarding self-sourced facilitators, content falling into the categories of perceived competence and experience of success appeared balanced. The remaining facilitator segments were distributed among mathematics (mostly in the sense of content), peers and environment, with 17, 11 and 8 segments, respectively. The narratives yielded 55 indicator segments (with an emotional emphasis) and 11 consequence segments. Six unrelated segments were found, mostly describing disengagement, which did not fit into the positively framed instruction of the study.

Overall, the students replied to the instruction with an average of 3.45 mentions of facilitators, indicators or consequences of engagement. Taken together, the recalled memories fit our conceptual framework.

Table 1

The system of codes, examples and frequencies

Engagement	Source of facilitation	Code	Definition	Example	Occurrence
Facilitator	Mathematics	Content	An element of the curriculum is mentioned.	...I liked combinatorics and graphs... (#55)	14 24.1%
	Mathematics	Positive opinion	Mathematics, as a subject, appears attractive.	...It is wonderful in mathematics that one thing can be approached from many directions... (#4)	3 5.2%
	Environment	School context	A school- or training-related specificity is mentioned.	...When we had double classes in mathematics... (#40)	8 13.8%
	Self	Perceived competence	The feeling of effectiveness and competence is mentioned.	...and finally, I could understand... (#50)	20 34.5%
	Self	Experience of success	The good experience of success is expressed.	...although I had a fear of that, I could nicely manage the task, with success... (#11)	17 29.3%
	Peers	Group content	The inspiration from group work and the good experience of working in a group are mentioned.	...we did not feel inferior when we could not understand something, we discussed everything in the group... (#40)	8 13.8%

Engagement	Source of facilitation	Code	Definition	Example	Occurrence
	Teacher	Supporting self-efficacy	The teacher provides tools for students that help them reach their goals.	...she made me calm, saying that the only thing I needed was some more practice and then it would help me not get stressed... (#57)	9 15.5%
	Teacher	Helpfulness & support	The teacher is approachable with problems, either related directly to the subject of the class or other concerns, and is ready to listen and help.	... continuously getting feedback from her... (#49)	6 10.3%
	Teacher	Friendly	The teacher is involved in maintaining a good atmosphere and positive interpersonal relationships.	...She taught us with love... (#42)	7 12.1%
	Teacher	Empirical learning	The teacher links the subject of the class to everyday life.	...she brought several kinds of liquid materials with her to the class and tried to explain to us with the help of a demonstration... (#34)	8 13.8%
	Teacher	Control	Based on expertise (in teaching and in mathematics), the teacher controls what happens in the class efficiently and purposefully.	...I liked really the way she organised the class... (#11)	16 27.6%
	Teacher	Challenge	The teacher challenges students' competencies by setting an unusual, demanding goal.	...We had a speed trial... (#10)	4 6.9%
Indicator		Behavioural engagement	The extra effort put into mathematics-related activities is mentioned.	...I paid very intense attention to the subject of the class... (#34)	9 15.5%
		Cognitive engagement	Self-regulating thinking about how to improve and where to get with mathematics, and what use of mathematics can be taken personally.	...since the good outcome was preceded by a huge amount of preparation... (#42)	14 24.1%
		Emotional engagement	Liking is expressed towards the subject, the classes or the teacher.	...I am very grateful to my teacher... (#42)	22 37.9%
Consequence		Academic success	Successful school leaving exam, good grades.	(my favourite memory is)...the successful school-leaving exam... (#17)	11 19.0%
Unrelated		Not Applicable	The content does not fit the positive frame.	...Mathematics is not my subject... (#14)	5 8.6%

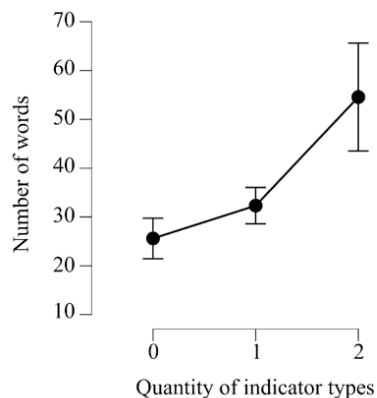
Note. Occurrences on the level of the individual participant.

The Validity of the Qualitative Content Analysis Method

It was expected that the recalled episodes would be valid manifestations of the students' past engagement. In order to test this expectation, the length (the number of words) of the written memories and indicators of engagement in the memories were examined. Figure 2 presents the average narrative length for respondents who mentioned none, one or two types of engagement (behavioural, emotional and cognitive) in their narratives. None of the respondents expressed all three types. A nonparametric Kruskal-Wallis H test was employed to determine whether there were significant differences between the three groups regarding the number of words. The results indicated a statistically significant difference between the groups regarding the number of words, there were significant differences between the groups regarding the number of words ($H(2) = 6.095, p = .047$).

Figure 2

The relationship between the two markers of engagement: the length of the narratives and the quantity of different types of engagement indicators appearing in the narratives



Note. Error bars show standard error.

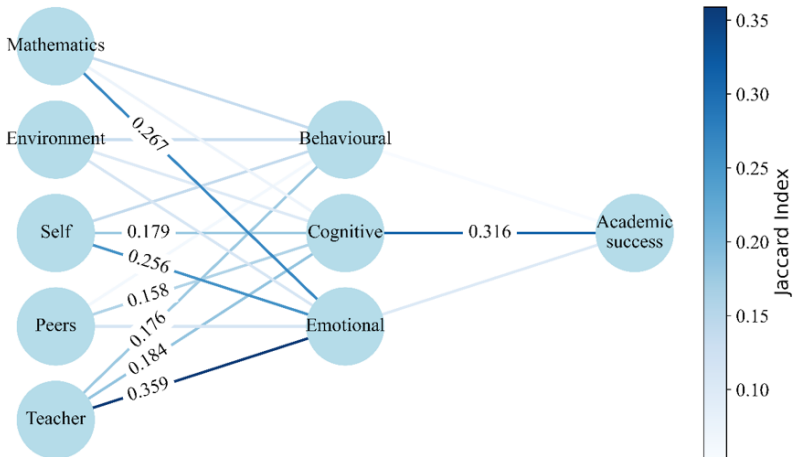
Examination of the Links Between Engagement Elements

Jaccard indices were used to examine the relationships between the specific facilitators, indicators and consequences of engagement. The Jaccard index, also called "Intersection over Union", measures the overlap between two categories: the number of participants with both categories was divided by the number of participants with either of the two categories.

Figure 3 shows connections related to the Facilitators-Indicators-Consequences model. The facilitators are grouped based on Table 1. Specific facilitator codes from the same source were merged into the source category for Mathematics, Self and Teacher sources to obtain interpretable co-occurrences. Thus, the analysis approaches facilitators on the source level: mathematics, environment, self, peers and teacher. Table 2 provides examples of the labelled relationships shown in Figure 3.

Figure 3

Connections between specific facilitators, indicators and consequences of engagement



Note. Links with Jaccard values $\geq .15$ are labelled.

The Jaccard index serves as an informative metric in our study, providing insights into patterns of co-occurrence within the dataset. Smaller metric values, approximately in the range from 0 to 0.3, should be approached with caution, as they indicate a comparatively limited degree of overlap between categories. Hence, although these connections suggest an association, the actual significance of these relationships may require further investigation. Although the Jaccard indices are small individually, their aggregate value underscores the role of facilitators (mathematics, self, peers, teacher) in engagement. The Jaccard index of 0.316 demonstrates the noteworthy relationship between academic success and cognitive engagement. In several narratives, this link took the form of an explicitly articulated self-regulation motif that invested effort yields

results. The elevated measure indicates a significant overlap and potentially a stronger association between these two categories.

Behavioural engagement is associated with teacher facilitation. Teachers are also facilitators of cognitive engagement, as are peers and the self. Emotional engagement is linked with three facilitator categories: most strongly (Jacard index of 0.359) with the teacher category, and to a considerable extent with mathematics and the self.

Table 2

Examples of connections between facilitators and indicators of engagement, as well as indicators and consequences of engagement

Connected content		Examples
Mathematics	Emotional engagement	...I really liked [<i>Emotional engagement</i>] the equations [<i>Mathematics, Content</i>] ... (#15)
Self	Cognitive engagement	One of the memorable moments from my math lessons was when I was the only one in the class who got the best mark on a test. [<i>Self, Experience of success</i>] It gave me a boost for further learning. [<i>Cognitive engagement</i>] (#3)
Self	Emotional engagement	I remember every math lesson fondly [<i>Emotional engagement</i>] because I understood everything I needed to [<i>Self, Perceived competence</i>] (#11)
Peers	Cognitive engagement	...It is perhaps a very good memory because I have always been the person who helps mates willingly [<i>Peers, Group content</i>]...I think this experience contributed a lot to my career choice to become a primary school teacher [<i>Cognitive engagement</i>]... (#9)
Teacher	Behavioural engagement	...Thanks to the win, my class teacher at the time took me [<i>Teacher, Control</i>] to several math competitions [<i>Behavioural engagement</i>]... (#10)
Teacher	Cognitive engagement	...Our teacher always assigned a lot of tasks [<i>Teacher, Supporting self-efficacy</i>], but it was worth it, as it contributed to our results [<i>Cognitive engagement</i>]... (#32)
Teacher	Emotional engagement	...I can recall the good atmosphere of classes [<i>Emotional engagement</i>]... With their friendly manner [<i>Teacher, Friendly</i>]... (#7)
Cognitive engagement	Academic success	...My school-leaving math exam was successful at a level of 93% [<i>Academic success</i>]...since I had been preparing for it intensively [<i>Cognitive engagement</i>]... (#42)

Note. Labels in parentheses (in italics) are codes from our coding system.

Discussion

The content analysis of preservice teachers' positive memories provided a valid window on mathematics engagement: engagement indicators co-occurred with longer narratives in line with prior findings on emotionally salient memories (Bohanek et al., 2005; Schaefer & Philippot, 2005). Behavioural engagement was rare, which is consistent with the target group's limited participation in extracurricular mathematics. The frequent mention of academic success likely reflects the salience of the recent school-leaving exam at the beginning of university studies.

The present study yielded observations consistent with the literature: mathematics teachers are essential facilitators of engagement in mathematics learning (e.g., Guo et al., 2019; Liu et al., 2018; Patrick et al., 2007; Simons-Morton & Chen, 2009). More than one quarter of the content (57 segments out of 206, 27.7%) concerned teachers. Importantly, more than half of the students mentioned their teacher. Professionalism, expertise and control had the highest frequency among teacher-related facilitators, indicating the importance students place on professionalism and expertise.

However, teachers' socioemotional characteristics (supporting self-efficacy, helpfulness and support, and friendliness) made up a considerable part (40%) of teacher-relevant facilitators. Exploring these characteristics, a large-scale Slovenian survey of 907 primary and secondary students revealed that mathematics lessons, particularly in primary schools, were perceived as less supportive and trusting than mother tongue classes (Kalin et al., 2017), underlining the importance of classroom climate as a key facilitator of engagement, a pattern that resonates with our findings. Our observation is also in line with the results of a study of Roche et al. (2023) focusing on how the engagement of underachieving students could be corrected with socioemotionally supportive methods. Our findings are also consistent with a study by Durksen et al. (2017), which emphasises the critical role of personalised teacher-student interactions in engagement and underscores the notion that fostering sustained engagement in mathematics learning extends beyond instructional strategies alone.

Mathematics-related facilitators were mentioned with a relatively low frequency (content, positive opinion, teachers giving challenging tasks or providing empirical learning), accounting for a total of 14.6% of the codes. This aligns with the finding that many preservice primary school teachers commence their training with a negative disposition towards mathematics (Panero et al., 2023). For these individuals, supportive teaching can be especially important in achieving better engagement.

In addition to teachers, the most frequent facilitators reported were self-experiences, perceived competence and experience of success, underlying the importance of empowerment in inducing engagement.

A remarkable link was found between peers as facilitators and cognitive engagement, demonstrating that the role of peers goes beyond enjoyable socialising; they also contribute a great deal to self-regulation via social comparison and social learning, as well as self-relevant social feedback.

The relationship between indicators of cognitive engagement (with self-regulating content) and academic success reflects the well-established relationship between self-regulated learning and academic success (e.g., Eshel & Kohavi, 2003; Guo et al., 2019; T.-H. Wang & Kao, 2022). In our data, this relationship was frequently articulated through a straightforward self-regulation motif, emphasising that effort produces results: participants characterised success in mathematics as the result of persistent effort.

Our results raise the question of the lasting impact of these positive school experiences on teacher candidates' professional self-image. Research on teacher identity formation shows that early school memories and field-based experiences interact in complex and sometimes contradictory ways. Empirical evidence based on teacher students' narratives from Finland indicates that teacher students' school memories are rarely addressed in training, although these concerns still plague students (Heikkilä et al., 2012). Moreover, in a recent study, Butler (2021) argues that the experiences gained in teaching practice during university years are not fully integrated into the professional identity of teacher candidates or their beliefs about successful teaching and learning. Although preservice teachers are skilled at adapting to environmental challenges and reporting on their experiences during the portfolio defence exam, they do so with a "temporary identity" (Butler, 2021, p. 55). As suggested by Butler, improving the efficacy of timely feedback from teachers supervising practice and the experiences discussed in university classes could contribute to solving the problem of identity formation; however, we are convinced that connecting the pedagogical curriculum to one's own past experiences from school years could also be helpful in this regard. The deliberate elicitation of memories related to learning mathematics and the examination of how these memories can serve as resources in developing teacher identity is a vivid topic in the pedagogical literature on preservice teacher education. Furthermore, personal narratives and remembered learning experiences are often treated as valuable tools for identity formation (Lutovac & Kaasila, 2018a, 2018b).

Limitations and Further Research

One limitation of the present research is the sample. Although the participants accounted for approximately 20% of first-year preservice primary school teachers nationally, caution should be exercised when extrapolating the results to preservice teachers in other education systems, or to any student with a comfortable but not very close relationship with mathematics. Furthermore, it should be remembered that the study identified correlations rather than causal relationships. Nevertheless, our observations provide a good starting point for further experimental research on causal relationships.

We are convinced that the method offers fruitful prospects for studying engagement in mathematics. Examination of the engagement of other students, especially students studying STEM subjects, would also be important. We assume that the identified socioemotional elements of teachers' activity remain facilitators of engagement, but we expect self-related facilitators (competence and success) and mathematics-related elements of teachers' activity (challenge, control, empirical learning), not to mention mathematics itself, to be connected to engagement.

Conclusion

The present study addressed the research question of how engagement in mathematics learning is reflected in preservice primary school teachers' written memories of their best mathematical experiences. The analysis showed that these memories are rich in emotional and cognitive engagement indicators but seldom describe behavioural engagement. These positive episodes were most often accompanied by teacher-related facilitating factors, particularly classroom control. In other words, professional guidance, as well as self-related facilitating factors, such as perceived competence and success, played a central role. Mathematics as a subject and peers were mentioned less frequently. Co-occurrence indices underlined the notion that academic success was closely aligned with cognitive engagement and that emotional engagement was strongly linked to the teacher.

Our methodology of recalling positive memories can also be considered as a practical component of the pedagogical curriculum, encompassing general lessons about the role of teachers in fostering positive experiences with learning mathematics. Moreover, learning the opinions of similar others can be very convincing in socialising for the profession and acquiring a teacher identity. We assume that the positive memories preservice teachers recall at the beginning of

their studies are also connected to their current needs. Based on this, we can say that in a supportive and well-managed training environment, preservice teachers may have a better chance of mastering the teaching profession.

Ethical Statement

The Ethics Committee of the Eszterházy Károly Catholic University, Hungary, ethically approved the research plan. The ethical permission number is RK/939/2022. By completing the questionnaire, the participants in the research consented to the anonymous use of their responses.

Data Availability Statement

The data for this study are deposited in Zenodo (<https://doi.org/10.5281/zenodo.12700212>).

Disclosure Statement

The authors declare that no conflict of interests exist. The authors declare that they have no affiliations with or involvement in any organisation or entity with any financial interest in the subject matter or materials discussed in this manuscript.

When preparing this article, the authors used ChatGPT (GPT-4) between 9 and 11 January 2026 with the following prompt, applied to multiple paragraphs of the manuscript: “Provide a condensed version of this paragraph that retains the essential analytical focus but omits redundant details”, for the purpose of language editing and concision. Grammarly was also used for language correction. The authors subsequently reviewed and edited the output as necessary and accept full responsibility for the content and integrity of the publication.

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