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Mathematics motivation in primary education: building blocks that matter

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Abstract
In this introduction, we set the stage for a collection of papers from the Co-constructing Mathematics Motivation in Primary Education–A Longitudinal Study in Six European Countries Project (MATHMot for short), an international study aiming to identify the factors that shape the development of motivation in mathematics from a comparative perspective in primary education. Students' motivation, performance, academic emotions, and subject-related identity and agency are observed across six countries: Norway, Sweden, Finland, Estonia, Portugal, and Serbia. MATHMot builds on the belief that one of the main goals of mathematics teaching should be children's long-term motivation for learning the subject, which in turn supports students in striving for exemplary achievement in mathematics. This special section attempts to observe students' mathematics motivation in early grades and how different contributions from the classroom, home or the student's individual characteristics shed light on its development and adjacent concepts like academic emotions and math-related identity and agency.

Keywords Motivation for mathematics · Achievement · Academic emotions · Mathematics identity · Student agency · Parents beliefs · Teacher beliefs · Primary school · Cross-country comparison · Gender · Grade

Co-constructing Mathematics Motivation in Primary Education–A Longitudinal Study in Six European Countries Project (MATHMot for short), which is funded by the Research Council of Norway, looks at the development of motivation in mathematics and what affects this process from an international viewpoint. The primary objective of the MATHMot project is to identify the factors shaping the development of motivation in mathematics from a comparative perspective in primary education. MATHMot builds on the assumption that one of the main goals of mathematics teaching should be children's long-term motivation for learning the subject, which aids them in striving for exemplary achievement

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in mathematics. Using the first wave data of the MATHMot project collected in Norway, Sweden, Finland, Estonia, Portugal and Serbia, this special section attempts to observe students' mathematics motivation in early grades and how different contributions from the classroom, home or the students' individual characteristics shed light on its development and adjacent concepts like academic emotions and math-related identity and agency.

Background

Across the fields of psychology of education and mathematics education, the vital role of how mathematics competence can facilitate student advancement in many domains later in life has long been recognised (OECD, 2013). At the same time, both fields have long passed the narrow idea of competence, acknowledging that mathematical competence entails more than mere knowledge of concepts, principles and structures (Rittle-Johnson, 2017). Over the years, multiple competency frameworks (e.g., Kilpatrick et al., 2001; Niss, 2003) have been developed (Radišić, 2023), finding their way into small- and large-scale studies. In parallel, fostering instructional environments that institute students' learning of mathematics as a 'dynamic playground', where students are deeply engaged with mathematics, has become paramount while searching for essential elements of teaching that could support these (Schoenfeld, 2014).

Even so, international large-scale assessment studies have pointed to significant cross-country variations in students' mathematics competency levels. The former variation also includes students' motivation to learn mathematics and their perception of their self-efficacy (Mullis et al., 2016, 2020; OECD, 2013). Recognising the importance of motivation is essential because students' motivation is seen as the driving force behind students' learning of mathematics over time (Eccles & Wigfield, 2020; Wigfield et al., 2016) and more and more as a desired outcome and a forgotten one when it comes to student learning outcomes (Radišić, 2023). The importance of motivation is coupled with a recent idea of the need to support strong competence self-perceptions (Marsh et al., 2017) and positive academic emotions (i.e., emotions directly tied to learning, instruction and outcomes in the school setting), which is grounded within Pekrun's control-value theory (Pekrun, 2017).

From the perspective of the expectancy-value theory (Eccles & Wigfield, 2020) and, more recently, situational expectancy-value theory (Eccles & Wigfield, 2023), competence self-beliefs and values attributed to the task are seen as the driving force behind students' motivation (Lauermann et al., 2017; Wigfield & Cambria, 2010). Concurrently, researchers have continually called for more research on the situational nature of motivational theories, including these theories' possible cultural specificity (Nolen, 2020; Schukajlow et al., 2023).

Across the literature, a positive relationship between motivation and achievement in mathematics is recurrently confirmed, irrespective of the theoretical approach followed (e.g., Kriegbaum et al., 2018; Prast et al., 2018). Some studies report motivation as predictive of mathematics competence (e.g., Murayama et al., 2013), while others observe the relationship as reciprocal over time (e.g., Luo et al., 2011). The measurement of mathematical competence varying across different studies between teachers' assessments and independent grade-specific tests has also been attributed to the diversity in the current results.

Although the number of studies observing the competence–motivation continuum is abundant, studies are more oriented towards single-country exploration. On the other hand, when a cross-country comparison is included, it is either limited to a bi-country

comparison, or in the case of large-scale international assessments like TIMSS and PISA, the observed aspects of motivation in connection to mathematical competence are limited. Furthermore, most studies observe middle school students and even older students (e.g., Arens et al., 2019; Benden & Lauermann, 2022), thus limiting knowledge of primary school development concerning motivation, competence and adjacent concepts such as academic emotions (Blažanin et al., 2024) and subject-related identity (Simpson & Bouhafa, 2020). Meanwhile, the field lacks studies observing students' motivational patterns in mathematics during transition periods (i.e., the shift in primary education from classroom to subject teaching). A cross-country perspective is even more important in capturing these changes, given the different organisation of education systems across Europe. These differences may include whether students stay with the same class teacher or move to subject teaching, remain in the same class versus change the class group or stay in the same school versus transition to a different school.

Conversely, student development, including motivation, does not occur in a vacuum. Thus, student background (e.g., socioeconomic status; Gustafsson et al., 2013; gender; Jacobs et al., 2002; Lazarides et al., 2017) is a crucial characteristic that contributes to this development and should be observed coupled with the home learning environment (Bradley & Corwyn, 2016; Martin & Lazendic, 2018). However, as learning mathematics is organised in the classrooms within schools, constrained by students' family characteristics and traits, examining teacher and school factors is needed, especially from the early development perspective.

In the context of the MATHMot project, all the aspects mentioned above were carefully crafted into the research design, choice of countries (i.e., education systems), samples and instruments used in the project. Thus, combining diverse perspectives and observing contributions from school and the home environment, the six papers in this special section aim to contribute to knowledge building by simultaneously observing the different factors that affect the development of motivation, emotions and identity in mathematics across diverse education sites during the early years of primary school. All papers examine data collected within the first wave of the MATHMot project, offering insights into the emerging mechanisms related to students' characteristics concerning motivation, affect and subject identity and teacher and parents' contribution to the process.

The content of the special section

Grounded in the expectancy-value perspective on identity and identity formation, the first study focuses on math identity and its relationship to task values, expectancies and achievement across different cultural contexts, here considering potential gender and grade differences (Radišić, Krstić et al., this issue). Although the authors establish different contributions of task values and expectancies to math identity, they also discuss gender differences not perceived across all the education systems studied. Though the study is cross-sectional, it shows that the grade 4 students perceived themselves less as 'math persons' than their grade 3 peers in all countries. It also shows the vital contribution of the education system in which a child is situated and the unique opportunities a system may provide for development.

The second paper further unravels the relationship between performance and confidence judgement and the mismatch between these, which is known as the

Dunning–Kruger effect (Yang Hansen et al., this issue). The study investigates how well students' confidence judgement and item-specific mathematics competence relate to each other and whether such a relationship differs across the six European countries involved in MATHMot. The author team also examines whether expectancy, math identity, gender, socioeconomic status and immigration background predict this mismatch and whether these demographic factors function differently between the examined countries. The results confirm that the Dunning–Kruger effect could be found across both examined grades and all six countries. However, country-specific patterns concerning the relationship between performance, math identity and expectancy value, the Dunning–Kruger effect and how different demographic variables predict its occurrences in particular subpopulations were found, corroborating the importance of the education system a child is situated in.

The third paper in this collection (Peixoto et al., this issue) focuses on parents' contributions to motivation development, drawing on the expectancy-value model and model of parents' socialisation of motivation. Recognising the myriad of potential family influences, the authors examine the association between parental beliefs and involvement and their children's motivation and mathematics achievement. The results indicate a detrimental impact of a fixed mindset on parents' practices. Furthermore, the authors discuss significant relationships between parents' attitudes towards mathematics, their practices and students' perceptions of math-related values and costs, as well as how these further tie to the child's outcomes. Notably, the authors draw possible implications for interventions aimed at parents.

The special section further examines the contributions of teachers concerning mathematics motivation. In the first such paper (Radišić, Buchholtz et al., this issue), the authors examine teachers' beliefs about the nature and learning of mathematics in connection to different aspects of task values and expectancies (i.e., intrinsic value, utility value and perceived competence) and enjoyment of mathematics across diverse education systems by considering students' mathematics achievement, gender and classroom composition (i.e., socioeconomic and behavioural). Although the results show students' intrinsic value and perceived competence positively relate to their enjoyment of mathematics in all six countries, country-level patterns were observed when examining how teachers' beliefs about the nature and learning of mathematics moderate the within-classroom relationship between boys and girls and the motivation and enjoyment of learning mathematics. Classroom socioeconomic and behavioural composition showed differential effects on teachers' beliefs, indicating particular country patterns. Again, gender differences were found, favouring boys in connection with their perceived competence.

Continuing their pursuit in the examination of teacher-level contributions, the last two studies in this section are examples of single country–driven explorations. Haataja et al. (this issue) examine whether Finnish elementary school students' socioeconomic status affects their mathematical competence and success expectancy, combined with the role of teachers' beliefs about mathematics learning. The study results underline the importance of teachers' constructivist beliefs about mathematics learning and class composition regarding students' special needs in predicting students' success expectancy. The authors also find that students with disadvantaged socioeconomic backgrounds need support on success expectancy to succeed in mathematics and that such support can be conveyed through teachers' constructivist pedagogical beliefs.

Finally, Leijen et al. (this issue) expand on the notion of motivation and focus on the adjacent concept of student agency in the context of the education system in Estonia. They observe how math teachers' beliefs on the nature of mathematics and self-efficacy

beliefs relate to different dimensions of student agency in primary education. The results showed that both self-efficacy beliefs and those on the nature of mathematics were related to students' agency dimensions.

The special section ends with a commentary by Eccles (this issue), which shows several advantages that bring together all the papers. Besides a solid set of measures used across them all, Eccles (this issue) underlines the variety of topics covered and the results stemming from the first wave of the MATHMot project. She also stresses how the section illustrates the benefit of bringing together sets of papers focused on similar issues with similar data sets. In addition, the commentary illustrates how the current collection of papers supports the importance of social cognitive approaches to educational psychology. Eccles (this issue) examines the importance of integrating multiple theoretical lenses in studying the development of motivated behaviour in academic settings and how some well-researched topics, through extensive examination, such as in this special section, have received new validation. Still, their re-examination has also opened new ways of thinking and rethinking about particular relationships on the development of motivation and adjacent concepts in the educational setting.

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Declarations

Competing interests The authors declare no competing interests.

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Current themes of research

Motivation for learning, academic emotions, teacher competence, teacher beliefs and instructional practices.

Relevant publications:

Radišić, J., Nortvedt, G. A., & Runde, R. K. (2023). Relationships Between Mathematics Self-Beliefs, Exposure to ICT In School, and Achievement on PISA 2012 Paper- and Computer-Based Mathematics Assessments. In C. Martin, B. Miller, & D. Polly (Eds.), Technology Integration and Transformation in STEM Classrooms (pp. 223-246). IGI Global. https://doi.org/10.4018/978-1-6684-5920-1

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Current themes of research

Motivation for learning, student achievements, student assessment, socio-cultural context in learning/teaching, social interaction in learning and development.

Relevant publications:

Peixoto, F., Radišić, J., Krstić, K., Hansen, K. Y., Laine, A., Baucal, A., Sõrmus, M., & Mata, L. (2023). Contribution to the Validation of the Expectancy-Value Scale for Primary School Students. J*ournal of Psychoeducational Assessment, 41*(3), 343–350. https://doi.org/10.1177/07342829221144868
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