Chapter # 13

EXPLORING THE RELATIONSHIP BETWEEN STUDENTS' MATHEMATICS SELF-EFFICACY AND MATHEMATICAL LITERACY

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ABSTRACT
Mathematics self-efficacy—the belief in one's ability to successfully perform mathematics-related tasks—has been consistently linked to improved mathematical performance and literacy. This study investigates the relationship between mathematics self-efficacy and mathematical literacy among Greek students at the end of compulsory education. A sample of 650 students from schools across major urban centers, small urban centers, and rural areas in Greece participated in the study. Mathematics self-efficacy was measured both as a single composite index and through four specific subcategories: (1) self-efficacy in solving abstract mathematical exercises, (2) self-efficacy in addressing real-world problems, (3) self-efficacy in mathematical literacy skills, and (4) self-efficacy in information literacy skills. The study aims to determine whether statistically significant correlations exist between students' performance in mathematical literacy and each of these dimensions of self-efficacy. The findings reveal a statistically significant positive correlation between overall mathematics self-efficacy and mathematical literacy performance. Furthermore, each of the four subcategories also demonstrated statistically significant positive correlations with mathematical literacy outcomes. These results underscore the multifaceted nature of mathematics self-efficacy and its critical role in supporting students' success in mathematical literacy, particularly as assessed in large-scale frameworks such as PISA.

Keywords: mathematical literacy, mathematics self-efficacy, compulsory education, Greece.

1. INTRODUCTION

Self-efficacy refers to an individual's belief in their capacity to achieve desired outcomes through their actions and abilities, functioning as a central motivational mechanism in overcoming challenges and difficulties (Bandura, 1994, 1997). It reflects the confidence individuals hold in their ability to organize and execute the behaviors required to attain specific goals (Delcourt & Kinzie, 1993). According to Bandura (1997), individuals with high levels of self-efficacy approach challenges with greater confidence, often drawing upon strategies that have proven effective in prior experiences. A key distinction between individuals with high and low self-efficacy lies in their persistence and resilience: highly self-efficacious individuals are more likely to persevere after failure and adopt alternative strategies, whereas those with lower self-efficacy may disengage or withdraw (Bandura, 1997; Usta, 2016).

Self-efficacy plays a critical role in students' academic success by shaping both their educational choices and their engagement in learning activities (Pajares & Miller, 1994; Sharma & Nasa, 2014). Within this broader framework, mathematics self-efficacy refers to individuals' beliefs in their ability to effectively engage with and successfully complete mathematics-related tasks, even when confronted with complexity or difficulty (Fast, Lewis, Bryant, Bocian, Cardullo, Rettig, & Hammond, 2010; OECD, 2013; Schunk, 1991; Stankov, Morony, & Lee, 2014). More specifically, mathematics self-efficacy encompasses students' confidence in managing a wide spectrum of mathematical demands, ranging from understanding fundamental concepts to solving complex and unfamiliar problems (Sharma & Nasa, 2014).

A substantial body of empirical research has consistently demonstrated a statistically significant positive relationship between mathematics self-efficacy and mathematics achievement (Anjum, 2006; Ayotola & Adedeji, 2009a, 2009b; Fast et al., 2010; Goodwin Ostrom, & Scott, 2009; Jiang, Song, Lee, & Bong et al., 2014; Pajares & Miller, 1994). This association has also been well documented with respect to mathematical literacy, particularly within large-scale assessment contexts (Cheema, 2018; Cheema & Galluzzo, 2013; Cheema & Skultety, 2017; Hiller, Kitsantas, Cheema, & Poulou, 2022; Kalaycıoğlu, 2015; Karakolidis, Pitsia, & Emvalotis, 2016a, 2016b; Lee, 2009; Lee & Stankov, 2013; OECD, 2004, 2013, 2023; Pitsia, Biggart, & Karakolidis, 2017).

In the present study, mathematical literacy is conceptualized in accordance with the most recent framework developed for the Programme for International Student Assessment (PISA 2022) (Nolka, 2025; Nolka & Sofianopoulou, 2024a, 2024b). Mathematical literacy is defined as students' capacity to formulate, employ, and interpret mathematics across a variety of contexts, including the ability to reason mathematically and to use mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena (OECD, 2019).

Although mathematics self-efficacy has often been examined as a single, global construct in previous research, the present study adopts a more differentiated approach. Initially conceptualized as a unified measure, mathematics self-efficacy is subsequently disaggregated into four distinct subdimensions: (a) self-efficacy in solving decontextualized mathematical exercises or equations, (b) self-efficacy in solving real-world, contextualized mathematical problems, (c) self-efficacy in competencies associated with mathematical literacy, and (d) self-efficacy in information literacy skills. This analytical distinction enables a more nuanced examination of how different facets of students' confidence relate to mathematical literacy performance.

While prior empirical studies have established a general positive association between mathematics self-efficacy and mathematical literacy, they have largely relied on unidimensional measures of self-efficacy or secondary data from large-scale assessments such as PISA. The present study extends the existing literature by empirically examining multiple, theoretically grounded dimensions of mathematics self-efficacy within an original assessment context. By distinguishing between symbolic, contextualized, literacy-related, and information-based self-efficacy, this study seeks to clarify the specific nature of the relationship between self-efficacy and mathematical literacy and to identify which dimensions of self-efficacy are most strongly associated with students' mathematical literacy performance.

2. RESEARCH

This study involved a sample of 650 students from various regions across Greece who were either in the final stage of the 9th grade or at the beginning of the 10th grade, corresponding to the completion or recent conclusion of compulsory education. Schools were selected based on the degree of urbanization of their location, ensuring representation from large urban centers, small urban centers, and rural areas. This diversity enhances the generalizability of the findings and provides a representative picture of students completing compulsory education in Greece.

To address the objectives of the research, two instruments were developed and administered: a mathematical literacy test and a questionnaire. The mathematical test consisted of five authentic real-world problems, subdivided into a total of eleven items. These were presented as word problems embedded in realistic contexts, each introduced by a contextual stimulus or narrative. Students' mathematical literacy achievement was operationalized as their performance on this test.

The mathematical tasks were designed to engage students in a range of mathematical processes and content domains. Across the test, students were required to work with proportional, quantitative, spatial, and data-related situations, applying mathematical modeling, reasoning, and interpretation rather than relying solely on routine procedures. The tasks varied in cognitive demand and required students to formulate mathematical relationships, employ appropriate procedures, interpret results within context, and justify their reasoning, in line with contemporary conceptualizations of mathematical literacy.

The second instrument, a questionnaire, consisted of 16 items developed to assess a mathematics self-efficacy index aligned with the PISA framework. The items reflected situations that require students to engage in mathematical reasoning and problem-solving in both abstract and real-world contexts. Responses were recorded on a four-point Likert scale, ranging from "not at all confident" (1) to "very confident" (4). This index captured students' perceived ability to apply mathematical knowledge and skills across a range of cognitively demanding tasks, consistent with the PISA construct of mathematical literacy. The instrument was designed to ensure content validity by incorporating tasks that span both disciplinary (pure mathematics) and contextualized (applied mathematics) domains, thereby providing a reliable measure of students' self-efficacy in line with international large-scale assessment standards.

The mathematics self-efficacy index was initially analyzed as a single composite construct encompassing all 16 items listed in Table 1. For more detailed analysis, the index was further disaggregated into four subcategories:

- Self-efficacy in solving mathematical exercises/equations without a real-world context (S.1–3).
- Self-efficacy in solving real-world problems within a contextual framework (S.4–9).
- Self-efficacy in the abilities of mathematically literate individuals (S.10–14).
- Self-efficacy in information literacy abilities (S.15–16).

Table 1.
Self- efficacy index.

Sentences	**How confident are you in your ability to succeed in the following mathematics tasks?**
1	To solve an equation like this: $3x+5=17$
2	To solve an equation like this: $6x^2+5=29$
3	To solve an equation like this: $2\cdot(x+3)=(x+3)\cdot(x-3)$
4	To calculate how much more expensive a computer will be after tax is added.
5	To calculate, based on a table of train schedules, how long it takes to get from one place to another.
6	To calculate how many square meters of tiles are needed to cover a floor.
7	To calculate the weekly consumption of an electronic device.
8	To find the actual distance between two places on a map with a scale of 1:10,000.
9	To calculate the properties of an irregularly shaped object.
10	To derive information from diagrams, graphs or simulations.
11	To interpret the mathematical solutions, you used to answer a problem in everyday life.
12	To recognize the mathematical aspects of a problem from real life.
13	To represent a situation mathematically, using variables, symbols or diagrams.
14	To understand scientific tables presented in an article.
15	To work with mathematical computing systems (e.g. excel, programming software, graphing calculators).
16	To write a code/program on computers.

The study aimed to address the following research questions:

- Is there a statistically significant correlation between mathematical literacy performance and overall self-efficacy in mathematics?
- Is there a statistically significant correlation between mathematical literacy performance and self-efficacy in solving mathematical exercises/equations without a real-world context?
- Is there a statistically significant correlation between mathematical literacy performance and self-efficacy in solving real-world problems?
- Is there a statistically significant correlation between mathematical literacy performance and self-efficacy in the abilities of mathematically literate individuals?
- Is there a statistically significant correlation between mathematical literacy performance and self-efficacy in information literacy abilities?

Ethical considerations were carefully addressed throughout the study. Participation was voluntary, and informed consent was obtained from both students and their legal guardians prior to data collection. Students were informed of the purpose of the study and assured that their responses would remain anonymous and confidential. No personally identifiable information was collected. The research procedures complied with institutional and national ethical guidelines for educational research involving minors.

3. RESULTS

3.1. Overall Mathematics Self-Efficacy

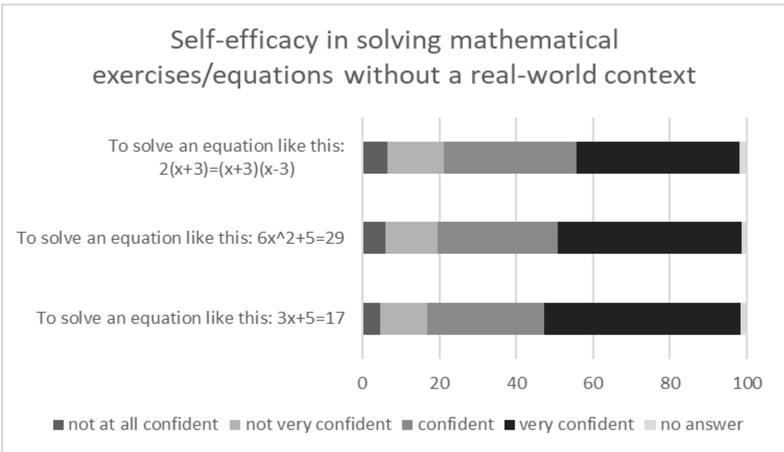
The descriptive findings indicate notable variation in students' self-perceived efficacy across different mathematical domains and task types. Among the items comprising the construct of mathematical self-efficacy, students expressed the highest levels of confidence in their ability to solve algebraic equations. Specifically, over 81% of participants reported feeling confident or very confident in solving a first-degree equation, while 79% indicated similar confidence for solving a second-degree equation. In contrast, the lowest levels of self-efficacy were observed in tasks involving spatial reasoning, particularly the calculation of properties of irregular shapes, with only 21.5% of students expressing confidence.

3.2. Self-Efficacy in Solving Symbolic Mathematical Exercises

Figure 1 illustrates students' self-efficacy regarding their ability to solve symbolic mathematical problems devoid of real-world context. These tasks include first- and second-degree equations and factored expressions, commonly encountered in formal mathematics instruction.

Students reported high levels of confidence in all three items. Over 81% felt confident or very confident in solving a linear equation (e.g., $3x + 5 = 17$), and similarly high percentages were observed for a standard quadratic equation ($6x^2 + 5 = 29$) and a factored expression ($2\cdot(x + 3) = (x + 3)\cdot(x - 3)$). These results suggest strong procedural fluency and familiarity with symbolic tasks, which are likely reinforced by school-based instructional practices that emphasize symbolic manipulation over applied problem-solving.

Figure 1.
Bar chart of students' self-efficacy (in %) regarding their ability to solve mathematical equations.

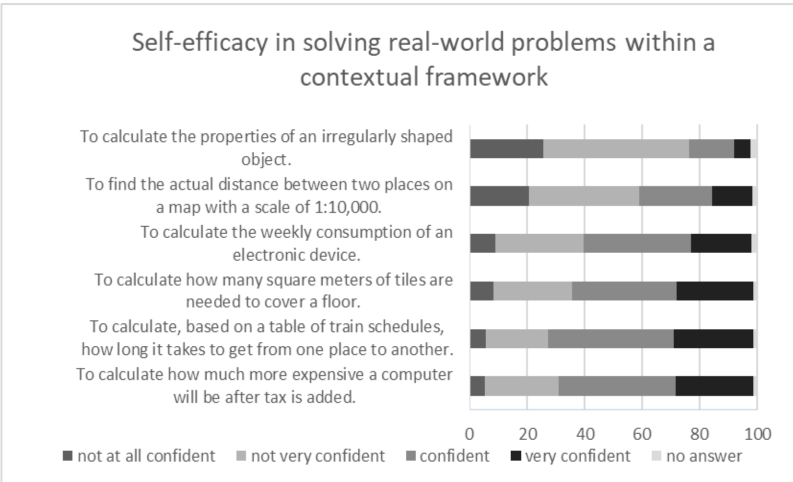


3.3. Self-Efficacy in Solving Real-World Mathematical Problems

Analysis of students' responses to real-world, context-based mathematical tasks revealed significant differences in self-efficacy based on task familiarity and complexity (Figure 2). Students reported greater confidence in routine, everyday applications of mathematics. For example, 71.5% of respondents expressed confidence or strong confidence in calculating the final cost of a computer after tax, and 68% felt similarly about using a train timetable to determine travel time. These results indicate a high level of perceived competence in solving familiar, routine problems grounded in everyday experience.

Conversely, tasks involving spatial or estimation-based reasoning were associated with significantly lower self-efficacy. Only 21.5% of students reported feeling confident in calculating the properties of irregular shapes, and 39.4% felt confident using a map scale to determine actual distances. These findings underscore a broader trend: while students feel confident in routine applications of mathematics, they experience difficulty and reduced self-efficacy in more cognitively demanding and less familiar contexts. The results highlight the importance of designing instructional strategies that build confidence in applying mathematical knowledge across diverse, non-routine, real-world situations, as emphasized in frameworks such as PISA.

Figure 2.
Bar chart of students' self-efficacy (in %) regarding their ability to solve real-world mathematical problems.

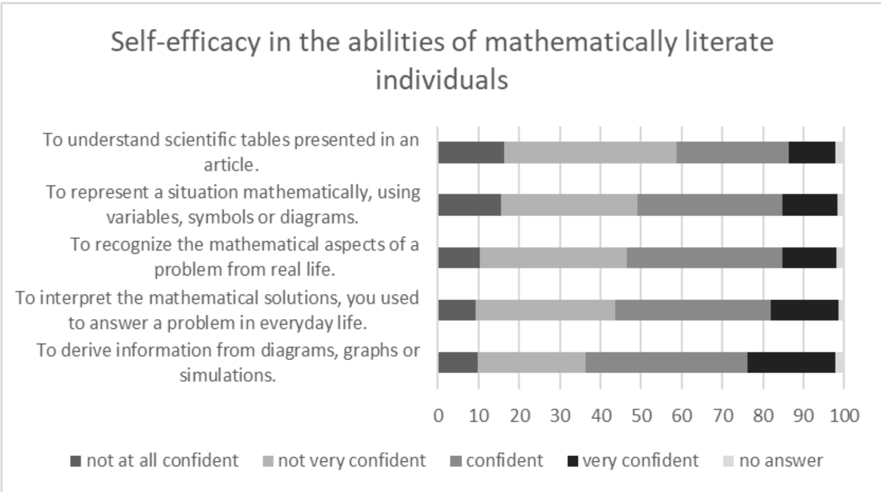


3.4. Self-Efficacy in Core Competencies of Mathematical Literacy

Figure 3 illustrates students' self-efficacy in performing key competencies associated with mathematical literacy, as defined by international assessment frameworks. Among the five competencies measured, students reported the highest confidence in interpreting visual representations (e.g., diagrams, graphs, simulations), with 61.7% feeling confident or very confident. Similarly, 55.1% expressed confidence in interpreting mathematical solutions to real-life problems.

Moderate confidence levels were observed for recognizing mathematical elements in real-world problems and for representing situations mathematically using appropriate symbols or models. Notably, only 39.2% of students reported feeling confident in interpreting scientific tables presented in articles—an ability often required in academic and informational texts. These results suggest a pattern in which students exhibit relatively strong confidence in visually supported reasoning but experience reduced self-efficacy when engaging with more abstract or technical forms of representation. Such disparities highlight the need for educational interventions that develop students' ability to navigate and interpret mathematically dense information across diverse media and contexts.

Figure 3.
Bar chart of students' self-efficacy (in %) regarding their ability to perform key competencies of mathematically literate individuals.



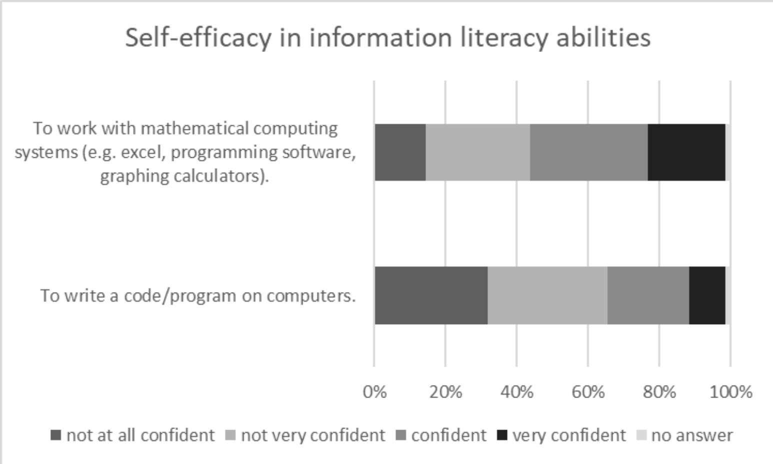
3.5. Self-Efficacy in Information Literacy Abilities

As shown in Figure 4, students' self-efficacy in information literacy abilities varies substantially between different types of digital tasks. A majority of students report low levels of confidence in writing computer code or programs, with 65.7% indicating that they feel "not at all confident" or "not very confident" in this activity. Only one third of the students report feeling confident or very confident in coding-related tasks.

In contrast, students demonstrate comparatively higher self-efficacy in working with mathematical computing systems such as spreadsheets, programming software, or graphing calculators. In this case, 54.9% of students report feeling confident or very confident, suggesting greater familiarity with using existing digital tools than with developing code independently.

This disparity highlights an important distinction between digital tool use and computational production. While students appear reasonably comfortable employing ready-made technological resources to support mathematical tasks, they exhibit considerably lower confidence in activities requiring algorithmic thinking and code creation. These findings underscore the need to strengthen computational and programming-related competencies within mathematics education, particularly as digital and AI-related skills become increasingly central to mathematical literacy.

Figure 4.
Bar chart of students' self-efficacy (in %) regarding their information literacy abilities.



3.6. Reliability and Correlational Analyses

To ensure the internal consistency of the self-efficacy constructs, Cronbach's alpha reliability tests were conducted. As shown in Table 1, all subscales of the self-efficacy in mathematics measure demonstrated acceptable reliability coefficients above the threshold of .700, with the exception of the "information literacy abilities" subscale, which comprised only two items.

Subsequently, Spearman's rho correlation analyses were performed to explore the relationships between students' self-efficacy beliefs and their performance in mathematical literacy. This non-parametric analysis was selected due to the non-normal distribution of the variables.

In the first stage, self-efficacy in mathematics was treated as a single composite variable. A statistically significant positive correlation was identified between this variable and performance in mathematical literacy ($r = .400$, $p < .01$), indicating that students with higher self-efficacy tend to achieve better outcomes.

In the second stage, the composite measure was disaggregated into four subscales to examine domain-specific associations. All four subcomponents were found to correlate positively and significantly with mathematical literacy performance:

- Self-efficacy in solving symbolic exercises/equations: $r = .338$, $p < .01$
- Self-efficacy in solving real-world problems: $r = .379$, $p < .01$
- Self-efficacy in mathematical literacy competencies: $r = .325$, $p < .01$
- Self-efficacy in information literacy abilities: $r = .086$, $p < .01$

Among these, the strongest correlation was observed between mathematical literacy performance and self-efficacy in solving real-world problems. This finding reinforces the importance of cultivating students' confidence and skills in applying mathematics beyond procedural tasks and toward complex, authentic problem contexts

In addition to the self-efficacy findings, overall performance on the mathematical literacy test indicates that students experienced varying levels of success across item types and cognitive demands. On average, students correctly solved fewer than half of the test items, with performance differing notably between multiple-choice and open constructed-response items. Higher success rates were observed on items requiring the application of familiar procedures, whereas lower performance was evident on tasks demanding mathematization, interpretation, and mathematical reasoning. Open constructed-response items, in particular, posed greater difficulty for many students (Nolka, 2025; Nolka & Sofianopoulou, 2025).

4. FUTURE RESEARCH DIRECTIONS

Building on the present findings, future research should aim to expand the scope of inquiry across diverse educational contexts. One promising direction involves broadening the study to include students from different grade levels, particularly earlier or later stages of secondary education, to explore how mathematics self-efficacy evolves over time. Additionally, conducting cross-national comparisons could reveal cultural or curricular influences on students' self-perceptions and performance, contributing to a more nuanced understanding of mathematical literacy across education systems. Another critical avenue for future investigation involves the design and implementation of targeted interventions that strengthen students' self-efficacy in specific subdomains where lower confidence was observed—such as interpreting scientific data or solving real-world problems involving spatial reasoning. Such interventions could combine pedagogical innovation with digital tools to foster both conceptual understanding and confidence. Longitudinal studies evaluating the impact of these interventions on performance and self-efficacy would further enrich the field, offering evidence-based strategies for enhancing students' mathematical resilience and preparedness for data-intensive and AI-mediated futures.

5. CONCLUSION / DISCUSSION

The analysis of the mathematical literacy test revealed that students experienced considerable difficulty in solving realistic problems requiring mathematical literacy skills. Performance was notably lower on tasks involving mathematization, interpretation, and mathematical reasoning, particularly in open constructed-response items. These results suggest that, by the end of compulsory education, students' mathematical literacy competencies are not yet sufficiently developed to support effective engagement with complex, real-world mathematical situations.

Against this backdrop, the findings of the present study provide a robust and empirically substantiated response to the research questions, confirming a statistically significant and positive relationship between students' mathematical literacy performance and their mathematics self-efficacy. This result is consistent with a substantial body of international research highlighting the central role of self-efficacy in predicting mathematical achievement (e.g., Hiller et al., 2022; Kalaycıoğlu, 2015; Karakolidis et al., 2016a, 2016b; Lee, 2009; OECD, 2004, 2013; Pitsia et al., 2017).

Importantly, mathematics self-efficacy was not treated as a single, undifferentiated construct. Instead, the 16-item scale was analytically decomposed into four theoretically grounded dimensions: (a) self-efficacy in solving decontextualized mathematical exercises and equations, (b) self-efficacy in solving real-world, contextualized mathematical problems, (c) self-efficacy in competencies associated with mathematical literacy, and (d) self-efficacy in information literacy. All four dimensions were found to be positively and significantly associated with mathematical literacy performance, with the strongest relationship observed for self-efficacy in solving real-world mathematical problems. This finding underscores the importance of context-based confidence in supporting students' success in literacy-oriented mathematical tasks.

In contrast to earlier studies that conceptualized mathematics self-efficacy as a global predictor of achievement, the present analysis demonstrates that the strength of its association with mathematical literacy varies meaningfully across different dimensions. The differentiated pattern of relationships observed in this study refines existing evidence by showing that not all forms of mathematical confidence contribute equally to literacy outcomes, thereby offering a more nuanced understanding of how self-efficacy operates within applied mathematical contexts such as those emphasized in PISA.

In sum, the findings of this study highlight the central role of mathematics self-efficacy in shaping students' mathematical literacy at the end of compulsory education. By adopting a multidimensional approach to self-efficacy, the study provides a more refined understanding of how different forms of confidence relate to students' ability to engage with mathematically demanding real-world tasks. The strong association observed between self-efficacy in solving real-world problems and mathematical literacy performance underscores the importance of instructional practices that emphasize contextualized problem-solving and reasoning. Taken together, these results contribute to the existing literature by offering empirical evidence that supports a differentiated conceptualization of mathematics self-efficacy within literacy-oriented assessment frameworks such as PISA.

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