MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2026, 22(10), em2923
ISSN:1305-8223 (online)
OPEN ACCESS Research Paper https://doi.org/10.29333/ejmste/19395

Professional orientation and task orientation of Spanish prospective secondary school mathematics teachers

María Soledad Salomón-Plata [1], José Manuel Diego-Mantecón [2*], José María Chamoso-Sánchez [1], María Mercedes Rodríguez-Sánchez [1]

[1] Departamento de Didáctica de las Matemáticas y las Ciencias Experimentales, Facultad de Educación, Universidad de Salamanca, Salamanca, SPAIN
[2] Departamento de Matemáticas, Estadística y Computación, Facultad de Ciencias, Universidad de Cantabria, Santander, SPAIN

Received 14 December 2025 ▪ Accepted 21 August 2026

Abstract
This study examines how 98 prospective secondary mathematics teachers (PTs) from five Spanish universities conceptualize professional orientation (PO) and task orientation (TO), and the extent to which both domains are integrated in their reflections after completing a one-year teacher education program. Using a qualitative approach, the study analyzed PTs' written reflections on mathematical and pedagogical knowledge and how it is applied in classroom practice for effective mathematics teaching. Results show a predominance of PO over TO. Key categories such as curriculum interpretation, specialized mathematical knowledge, collaborative participation, and challenging tasks appeared less frequently. Although some PTs integrated PO and TO categories, they emphasized what mathematics teachers should know more than how this knowledge is translated into classroom practice. The findings highlight the need to strengthen opportunities within initial teacher education to connect mathematical and pedagogical knowledge with classroom practice, particularly through practice-based experiences.

Keywords: professional orientation, task orientation, initial teacher education, prospective mathematics teachers, secondary education

INTRODUCTION

Initial mathematics teacher training remains a central concern in countries such as Spain, where competency-based curricular reforms and societal demands for mathematical literacy have intensified expectations regarding teacher preparation (Sevillano & Sánchez, 2021). Effective initial training provides the foundations for fostering meaningful mathematics learning (Muñiz-Rodríguez et al., 2020; Rodríguez-Alveal et al., 2019) and adapting instruction to students' needs (Nascimento et al., 2021). However, integrating mathematical and pedagogical knowledge into classroom practice remains a persistent challenge, particularly within competency-based curricula (Falcón-Linares, 2021; Iturbe-Sarunić & Silva-Hormazábal, 2022). Identifying prospective secondary mathematics teachers' (PTs) views of what it means to be a good mathematics teacher is key to evaluating initial training (Rodríguez-Alveal et al., 2019; Solano-Díaz et al., 2022).

Two constructs provide an analytical lens for evaluating initial training: professional orientation (PO) and task orientation (TO). PO refers to teachers' views of what is important in their work, particularly what they should know, while TO focuses on how this knowledge is applied in classroom practice (Lamote & Engels, 2010; Nickel & Crosby, 2021). Although both constructs have been examined in previous research, they have typically been studied separately (e.g., Nickel & Zimmer, 2018), through quantitative approaches (e.g., Meyer et al., 2023), or across multiple subject areas (e.g., Lamote &

María Soledad Salomón-Plata was a PhD student under the supervision of Professors Diego-Mantecón, Chamoso-Sánchez, and Rodríguez-Sánchez during the preparation of this article.

✉ msalomonp@usal.es ✉ diegojm@unican.es **(*Correspondence)** ✉ jchamoso@usal.es ✉ meros@usal.es

Contribution to the literature

- This study examines how PTs integrate PO and TO within a consecutive teacher education model.
- PTs emphasize PO more strongly than TO, whereas the integration between teacher knowledge and classroom practice remains uneven and limited.
- Specialized mathematical knowledge, curriculum knowledge, collaborative participation, and challenging tasks appear less prominently, highlighting key areas for improvement in teacher education programs.

Engels, 2010), resulting in a limited understanding of how PTs integrate these domains (Meyer et al., 2023).

Against this background, the present study adopts a qualitative approach to examine Spanish PTs' views on the knowledge they should possess (PO), how this knowledge should be applied in classroom practice (TO), and the extent to which both domains are integrated (PO + TO). Specifically, the study analyses the reflections of 98 PTs from five universities in Spain, aiming to provide insight into the effectiveness of initial teacher education within the consecutive model.

MATHEMATICS TEACHER EDUCATION AND COMPETENCY-BASED FRAMEWORKS

The preparation of PTs must be understood within the context of competency-based curricula, which require integrating knowledge, skills, and dispositions to address classroom demands (Iturbe-Sarunić & Silva-Hormazábal, 2022). This approach has been promoted through European initiatives such as the OECD Learning Compass 2030 (OECD, 2019) and progressively adopted in Spain through successive educational reforms, culminating in the LOMLOE (2020), which establishes competency-based learning as a central foundation of the educational system (Azcárraga, 2022; López Rupérez, 2022). Within this context, teachers are expected not only to master mathematical and pedagogical content but also to translate it into instructional experiences that foster reasoning, critical thinking, and problem-solving (Sevillano & Sánchez, 2021). This shift places increasing demands on initial teacher education programs.

Prospective teachers typically complete an initial teacher education program to enter secondary school teaching (Falcón-Linares, 2021). Two main models predominate: concurrent and consecutive. The concurrent model combines disciplinary and pedagogical training over four to six years (Oviedo & Lizárraga, 2022; Sevillano & Sánchez, 2021) and is used in countries such as Belgium, Finland, Singapore, and the Netherlands (Zuzovsky & Donitsa-Schmidt, 2017). In contrast, the consecutive model comprises two stages: a disciplinary degree followed by one or two years of pedagogical training (Lorenzo-Vicente et al., 2015; Pérez et al., 2021), as adopted in countries like Spain, France, and Italy. Other countries, such as Norway, the United Kingdom, and Austria, combine both approaches (Falcón-Linares, 2021; Lorenzo-Vicente et al., 2015). Each model presents advantages and limitations. The concurrent approach promotes closer integration between disciplinary and pedagogical training (Falcón-Linares, 2021; Nascimento et al., 2021), although disciplinary content may be addressed with less depth (Sevillano & Sánchez, 2021). The consecutive model provides strong disciplinary preparation but a more limited and less integrated pedagogical foundation (Prendes et al., 2021), which may lead to a mismatch between training and classroom demands (Lorenzo-Vicente et al., 2015).

Spain follows a consecutive model, which tends to result in strong disciplinary knowledge but more limited pedagogical preparation, reducing opportunities to apply this knowledge in classroom practice (Lorenzo-Vicente et al., 2015) and creating tensions with the demands of competency-based education (Sevillano & Sánchez, 2021). From this perspective, the structure of initial teacher education becomes a key factor in connecting knowledge with teaching practice. This relationship can be examined through the dimensions of PO and TO (Lamote & Engels, 2010; Nickel & Zimmer, 2018).

CONCEPTUALIZATIONS OF PROFESSIONAL ORIENTATION AND TASK ORIENTATION

Professional Orientation

PO refers to teachers' interpretations of what is important in their work, particularly what they should know and how they should act (Lamote & Engels, 2010; Nickel & Crosby, 2021). In mathematics education, it can be conceptualized through frameworks such as mathematical knowledge for teaching (Ball et al., 2008), comprising the subdomains of subject matter knowledge (SMK) and pedagogical content knowledge (PCK). SMK concerns the mathematical knowledge needed for teaching and includes common content knowledge (CCK), specialized content knowledge (SCK), and horizon content knowledge (HCK). CCK refers to the mathematical knowledge that any literate adult might possess and is not exclusive to teachers (Ruiz et al., 2023; Spitzer & Phelps-Gregory, 2024). It encompasses knowledge and skills used in everyday or professional contexts beyond teaching (Almeida & Pietropaolo, 2022;

Tefera et al., 2021). In contrast, SCK is specific to mathematics teachers and supports the specialized work of teaching. That is, this knowledge is defined as the mathematical understanding required for instructional tasks such as representing ideas, justifying procedures, and evaluating atypical problem-solving approaches (Pincheira & Alsina, 2021). HCK refers to knowledge of the relationships among mathematical topics, addressing content at different levels of difficulty, and linking mathematics with other fields (Arnal-Bailera & Oller-Marcén, 2020).

PCK relates to the knowledge that integrates mathematical content with pedagogy and includes knowledge of content and curriculum (KCC), knowledge of content and teaching (KCT), and knowledge of content and students (KCS). KCC is understood as the knowledge of instructional programs and materials for developing or facilitating mathematics learning (Almeida & Pietropaolo, 2022; Ball et al., 2008). KCT is defined as knowledge of instructional design, encompassing teaching strategies, assessment, resources, and tasks (Ball et al., 2008; Ruiz et al., 2023). KCS encompasses the knowledge of how students think about, understand, or learn particular mathematical content, which helps adapt instruction to student needs (Arnal-Bailera & Oller-Marcén, 2020). Together, these categories reflect the knowledge dimension of teaching and support effective instructional practices (Ball et al., 2008).

Task Orientation

TO refers to teachers' perceptions of how instructional goals are achieved in classroom practice, particularly through the design and implementation of tasks with defined learning objectives (Lamote & Engels, 2010; Rohmah et al., 2019). It reflects the practical dimension of teaching, focusing on how knowledge is put into practice (Lamote & Engels, 2010). TO can be analyzed through three subdomains: mathematical content, promotion of participation, and consideration of student learning (Li & Stylianides, 2018). Mathematical content refers to the instructional decisions made during the learning process regarding how it is presented, developed in lessons, and supported by appropriate resources. Two key categories are highlighted: the use of challenging tasks and technological resources (Albert et al., 2021). Challenging tasks lack a predetermined solution method and often involve open or real-life problems used in project-, problem-, or discovery-based learning (Sullivan et al., 2015). Technological resources encompass digital tools—devices, software, or applications—that support understanding and enhance mathematical tasks (Albert et al., 2021).

Promotion of participation concerns instructional decisions that shape how students engage in the learning process, commonly described in terms of autonomous and collaborative participation (Bonesrønning et al., 2022; Li & Hu, 2024; Zhang et al., 2021). Autonomous participation involves activities carried out independently, fostering self-regulation, decision-making, and self-directed learning, individually or in whole groups (Campbell & Hodges, 2020; Du et al., 2025; Prast et al., 2025). Collaborative participation occurs when students work together toward shared goals, emphasizing interdependence, interaction, and the social construction of knowledge, usually in small heterogeneous or homogeneous groups (Francome & Hewitt, 2018; Gardesten & Palmér, 2023). Consideration of student learning involves instructional decisions for each student and their reflection on the learning process, emphasizing critical thinking and adaptive teaching (Wafubwa & Csíkos, 2022). Critical thinking is the ability to analyze, evaluate, interpret, and synthesize information to make informed decisions and solve problems (Sachdeva & Eggen, 2021). It is fostered through effective questioning—checking prior knowledge, prompting reflection, encouraging inquiry, and identifying errors—and by turning student mistakes into learning opportunities (Alvidrez et al., 2024; Dresel et al., 2025; Kyaruzi et al., 2020). Adaptive teaching adjusts instruction to student needs, abilities, pace, and learning styles, relying on flexible methodologies and continuous formative assessment to guide adaptations (Boström & Palm, 2023; Hwang et al., 2020).

RESEARCH ON PROFESSIONAL ORIENTATION AND TASK ORIENTATION IN PROSPECTIVE TEACHERS

Earlier research has often studied PO and TO separately, with limited attention to their integration. Regarding PO, studies such as Newton et al. (2022) and Sapkota (2025) have examined specific categories but have not addressed their alignment with TO categories. These studies found that, although prospective teachers recognize the importance of mathematical and pedagogical knowledge, some categories are more often articulated than others. For instance, Sapkota (2025) found that PTs frequently refer to KCT, KCS, KCC, and CCK, with less attention to HCK. Similarly, Newton et al. (2022) described frequent references to CCK and KCT, but limited attention to SCK. Kuennen and Beam (2020) and Stylianides and Stylianides (2023) reported a lack of emphasis on KCC. Wong and Liu (2022), drawing on a professional identity perspective (Beijaard et al., 2004), recognized various PTs' allusions to categories of mathematical and pedagogical knowledge.

Regarding TO, studies such as Alvidrez et al. (2024), Boström and Palm (2023), Du et al. (2025), and Ingram et al. (2020) have examined specific categories but have not addressed their alignment with PO categories. These studies have shown that, although PTs are aware of the importance of several TO categories, they often struggle to implement them in practice. For example, Albert et al. (2021) and Ingram et al. (2020) examined the challenging tasks and technological resources categories within the mathematical content subdomain, showing that PTs perceive them as important, although they often struggle to implement such practices and maintain cognitively demanding activities. Similarly, Du et al. (2025) and Sullivan et al. (2015) focused on autonomous and collaborative participation categories within the promotion of participation subdomain, showing that although PTs value both categories, they often experience difficulties implementing the collaborative one. In the same vein, Alvidrez et al. (2024), Boström and Palm (2023), and Uygun (2020) found that PTs recognized the importance of adaptive teaching and critical thinking within the consideration of student learning subdomain, but experienced difficulties in applying formative assessment and using errors as learning opportunities.

Importantly, research examining the relationship between PO and TO remains limited, providing little insight into how the two domains are integrated. This is evident in studies such as Lamote and Engels (2010), Nickel and Crosby (2021), and Nickel and Zimmer (2018), which typically approach these domains from a professional identity perspective (Beijaard et al., 2004) and involve teachers from various disciplines. For instance, Nickel and Zimmer (2018) observed that prospective teachers trained within consecutive models referred more frequently to PO than TO. In contrast, Nickel and Crosby (2021), also within a consecutive model, reported a stronger emphasis on TO, reflected in commitment to students' learning. Similarly, Lamote and Engels (2010), studying prospective teachers trained through a concurrent model, found a stronger emphasis on TO than on PO. However, none of these studies explicitly examined how the categories of both domains relate. Given the limited evidence on their integration, examining the relationship between PO and TO remains essential. In addition, qualitative studies are needed to understand this relationship in depth and to complement the predominantly quantitative literature. Exploring how PTs connect mathematical and pedagogical knowledge with classroom practice may provide deeper insight into their views of effective mathematics teaching and inform initial teacher education programs.

RESEARCH QUESTIONS AND METHODS

Given the limited understanding of how PTs integrate PO and TO, particularly in the context of competency-based curricular reforms, it is important to examine how they conceptualize these domains at the end of their initial preparation. Accordingly, this study addresses the following research question: How do PTs conceptualize PO and TO, and to what extent are both domains (PO + TO) integrated in their reflections on effective mathematics teaching? The findings are expected to provide insight into the strengths and limitations of current initial teacher education programs. To address this question, a qualitative research design was adopted. Data were collected through open-ended questionnaires, complemented by individual interviews aimed at exploring selected responses in greater depth and providing additional interpretative insight.

Participants' Selection and Description

The study involved 98 PTs (40 male, 58 female), aged 22-45, enrolled in the master's degree in secondary education teacher training (mathematics specialization) at five Spanish public universities, distributed as follows: Salamanca (25%), Valladolid (12%), Cantabria (12%), Granada (38%), and Cádiz (13%). These proportions reflect the size of the annual cohorts at each university. Participants held undergraduate degrees in mathematics (48%), engineering (28%), architecture (14%), and physics (10%), reflecting disciplinary backgrounds eligible for admission to the program, with similar distributions across institutions and suggesting comparable participant profiles. The master is mandatory for becoming a secondary education teacher (ages 12-18) and comprises 60 ECTS (1,500-1,800 hours) over one academic year. It is organized into three modules: a generic module (12 ECTS) covering learning and development in educational and social contexts; a specific module (24 ECTS) focused on mathematics pedagogy and educational research; and a practical module (16 ECTS) including a teaching school practice and a master's thesis. In addition, the program offers 8 ECTS of elective courses. The training structure is consistent across institutions, differing only in the organization of school practices. Valladolid, Cádiz, and Cantabria split these practices into two periods across the academic year, whereas Salamanca schedules a single period after the theoretical lessons, and Granada adopts a mixed approach.

Procedure and Methods

Data were collected during a two-hour session at the end of the academic year, after completing both theoretical lessons and teaching school practice. The session comprised two parts. In the first (30 minutes), participants completed an introductory reflective task adapted from Flores and Day (2006). They were asked to recall their experiences as mathematics learners during secondary school, describe a typical mathematics class, and reflect on their mathematics teachers' practice. The second part (90 minutes) consisted of a questionnaire designed to elicit reflections on the mathematical and pedagogical knowledge teachers should possess, and how this knowledge should be put into practice. The questionnaire was based on previously validated instruments used in similar educational contexts

Table 1. PO subdomains, categories, and indicators (adapted from Ball et al., 2008)

Subdomains	Categories	Indicators
Subject matter knowledge *Knowledge of mathematical content needed for teaching*	'Common content knowledge'	- *Performing basic calculations* - *Recognizing incorrect answers* - *Identifying numbers within given intervals* - …
	'Specialized content knowledge'	- *Representing mathematical ideas* - *Explaining rules and procedures* - *Analyzing student errors* - …
	'Horizon content knowledge'	- *Connecting current teaching to future learning* - *Explaining the evolving number line* - *Applying mathematics beyond school subject* - …
Pedagogical content knowledge *Knowledge of the relationship between mathematical content and pedagogy used to teach it*	'Knowledge of content and curriculum'	- *Using curriculum materials* - *Aligning teaching with educational standards* - *Identifying curriculum progression* - …
	'Knowledge of content and teaching'	- *Selecting effective examples and representations* - *Designing instructional activities* - *Explaining concepts clearly* - …
	'Knowledge of content and students'	- *Anticipating student misconceptions* - *Predicting areas of student difficulty or interest* - *Understanding sources of confusion* - …

(Contreras, 2016). It included questions such as: "Please indicate which types of knowledge you consider essential for teaching and learning of mathematics at the secondary level" and "Please explain what kind of secondary education teacher you would like to become, and the implications this would have for mathematics teaching and learning." To encourage engagement and avoid superficial responses, the task was part of the course assessment, following Chamoso and Cáceres (2009). Participants were informed that evaluation would focus on the depth of reflection rather than the content of their answers. Following the session, a subset of participants was purposefully selected for individual semi-structured interviews to explore further their written reflections, in line with Albay and Cetin (2023). Participation was voluntary, resulting in a final sample of 41 interviews, each lasting 25-35 minutes.

Data Analysis

The data were analyzed qualitatively using content analysis (Nicmanis, 2024). First, PTs' reflections were segmented into 1,787 information units and classified into the PO or TO domains based on their content. These units were then allocated to subdomains and categories using a theory-driven coding scheme (Ball et al., 2008; Li & Stylianides, 2018) based on predefined indicators. The coding followed a deductive approach using this scheme, without generating additional subdomains or categories. **Table 1** presents the coding scheme for the PO domain, including examples of indicators associated with the knowledge teachers should possess within each subdomain and category. Within **SMK**, *performing basic calculations* and *recognizing incorrect answers* were associated with 'CCK', whereas *representing mathematical ideas* and *analyzing student errors* corresponded to 'SCK'. Indicators such as *connecting current teaching to future learning* and *applying mathematics beyond the school subject* were linked to 'HCK'. Within **PCK**, *using curriculum materials* and *identifying curriculum progression* were associated with 'KCC', while *selecting effective examples* and *designing instructional activities* corresponded to 'KCT'. Finally, *anticipating student misconceptions* and *understanding sources of confusion* were linked to 'KCS'.

As presented in **Table 2**, a similar scheme was used for the TO domain, referring to how mathematical and pedagogical knowledge is enacted in classroom practice. Within **mathematical content**, *implementing problem-based learning* and *project-based learning* were assigned to 'challenging tasks', while the *use of technological resources* corresponded to 'technological resources'. Within **promotion of participation**, *individual* and *whole-group work* were classified as 'autonomous participation', whereas *work in small heterogeneous or homogeneous groups* was associated with 'collaborative participation'. Within **consideration of student learning**, *asking questions* and *encouraging reasoning and reflection* were linked to 'student critical thinking', while the *use of prior knowledge* and *formative assessment* corresponded to 'adaptive teaching'.

The final stage focused on analyzing the integration of PO and TO by examining the number of categories from each domain identified in participants' responses. As both domains comprise six categories, levels of

Table 2. TO subdomains, categories, and indicators (adapted from Li & Stylianides, 2018)

Subdomains	Categories	Indicators
Mathematical content *Instructional decisions related to mathematical content in the learning process*	'Challenging tasks'	*- Implement problem-based learning* *- Implement project-based learning* *- Implement inquiry-based learning* *- …*
	'Technological resources'	*- Use of technological resources* *- …*
Promotion of participation *Instructional decisions related to student engagement in the learning process*	'Autonomous participation'	*- Individual work* *- Whole-group work* *- …*
	'Collaborative participation'	*- Work in small student groups* *- Work in heterogeneous or homogeneous groups* *- …*
Consideration of student learning *Instructional decisions for each student and their reflection on the learning process*	'Student critical thinking'	*- Asking questions* *- Taking advantage of mistakes* *- Encouraging reasoning and reflection* *- …*
	'Adaptive teaching'	*- Use of prior knowledge* *- Conducting formative assessment* *- Consider students' interests* *- …*

Table 3. Integrating PO and TO categories

	High ≥ 5 PO categories	**Partial** ≥ 3 PO categories	**Minimal** ≥ 1 PO category
High ≥ 5 TO categories	6 PO + 6 TO; 6 PO + 5 TO; 5 PO + 6 TO; 5 PO + 5 TO	4 PO + 6 TO; 4 PO + 5 TO; 3 PO + 6 TO; 3 PO + 5 TO	2 PO + 6 TO; 1 PO + 6 TO; 2 PO + 5 TO; 1 PO + 5 TO
Partial ≥ 3 TO categories	6 PO + 4 TO; 6 PO + 3 TO; 5 PO + 4 TO; 5 PO + 3 TO	4 PO + 4 TO; 4 PO + 3 TO; 3 PO + 4 TO; 3 PO + 3 TO	2 PO + 4 TO; 2 PO + 3 TO; 1 PO + 4 TO; 1 PO + 3 TO
Minimal ≥ 1 TO category	6 PO + 2 TO; 6 PO + 1 TO; 5 PO + 2 TO; 5 PO + 1 TO	4 PO + 2 TO; 4 PO + 1 TO; 3 PO + 2 TO; 3 PO + 1 TO	2 PO + 2 TO; 2 PO + 1 TO; 1 PO + 2 TO; 1 PO + 1 TO

integration were operationalized using three thresholds: high (at least five categories), partial (at least three), and minimal (at least one). Each participant was assigned to the corresponding cell of a double-entry table (**Table 3**) according to their PO-TO category combination, and percentages were calculated for each cell. To ensure consistency, an inter-coder triangulation process was implemented. Three authors independently conducted the analysis, while a fourth author reviewed it. Agreement levels were high (97.0% for PO and 92.2% for TO). Discrepancies were resolved through discussion until full agreement was reached.

RESULTS

Table 4 summarizes PTs' reflections on the PO and TO domains. References to PO were more frequent, with 87% alluding to **PCK** and 100% to **SMK**. Several category combinations were observed in PO, particularly in **SMK,** involving up to three categories. In contrast, TO appeared less consistently, with references ranging from 49% in **mathematical content** to 68% in **promotion of participation,** and with fewer category combinations.

Professional Orientation

Eighty-seven per cent of the PTs alluded to PO through both **SMK** and **PCK**. Within **SMK**, 25% of PTs referred simultaneously to the three categories: 'CCK', 'SCK', and 'HCK'. The PTs alluded to 'CCK' in items like *"A teacher must have mathematical knowledge"* (PT-17); to 'SCK' in statements like *"Logical-deductive reasoning developed during the degree is really useful …"* (PT-47); and to 'HCK' when noting *"A teacher should know current applications of maths in diverse fields"* (PT-59). About 50% of the PTs referred to at least two categories within **SMK**: 31% combined 'CCK' and 'HCK', while 22% combined 'CCK' and 'SCK'. These findings suggest that PTs recognize the importance of **SMK** subdomain for effective teaching. Nobody combined 'SCK' and 'HCK', which may reflect, as suggested in the semi-structured interviews, having received limited instruction on applying specialized mathematical content to real-world problems. As PT-17 stated, *"Honestly, I haven't really done any tasks during my degree involving specific aspects of maths applied to real-world contexts"*.

Regarding **PCK**, 14% of the PTs alluded to its three categories: 'KCC', 'KCT', and 'KCS'. This combination was illustrated by PT-55 when stating: *"A teacher must know the curriculum"* (KCC); *"[a teacher] must know diverse methodologies to choose the best option at each moment"*

Table 4. Percentages of category combinations within the PO and TO subdomains

Domains	Subdomains	Combining Categories	P (%)
Professional orientation (PO)	**Subject matter knowledge** (100%)	'Common content knowledge'; 'Horizon content knowledge'; 'Specialized content knowledge'	24.5
		'Common content knowledge'; 'Horizon content knowledge'	30.7
		'Common content knowledge'; 'Specialized content knowledge'	22.4
	Pedagogical content knowledge (87%)	'Knowledge of content and teaching'; 'Knowledge of content and students'; 'Knowledge of content and curriculum'	14.3
		'Knowledge of content and teaching'; 'Knowledge of content and students'	34.7
		'Knowledge of content and teaching'; 'Knowledge of content and curriculum'	10.2
Task orientation (TO)	**Mathematical content** (49%)	'Challenging tasks'; 'Technological resources'	10.2
	Promotion of participation (68.3%)	'Autonomous participation'; 'Collaborative participation'	11.2
	Consideration of student learning (65.3%)	'Student critical thinking'; 'Adaptive teaching'	14.3

Note. P: Percentage

Table 5. Integration of PO and TO categories and percentages

	High	Partial	Minimal
High	4.1% high PO + high TO	0% partial PO + high TO	0% minimal PO + high TO
Partial	**8.2%** high PO + partial TO 5 PO + 4 TO	**25.5%** partial PO + partial TO 4 PO + 4 TO	4.1% minimal PO + partial TO
Minimal	**11.2%** high PO + minimal TO 5 PO + 1 TO	**29.6%** partial PO + minimal TO 4 PO + 2 TO	2.1% minimal PO + minimal TO

(KCT); and *"It's important to know the levels of learning and students' cognitive difficulties"* (KCS). Regarding combinations of two categories, the most frequent was 'KCT' and 'KCS', shown by 35% of PTs; a smaller proportion (10%) combined 'KCC' and 'KCT'. None joined 'KCS' and 'KCC', which may reflect the limited emphasis in their training on connecting student learning with curricular design. As PT-84 stated during the interview, *"We often focus on student difficulties and curriculum requirements, but we don't really learn how to connect the two in practice"*. Overall, these findings suggest less emphasis on **PCK** than on **SMK**.

Task Orientation

Regarding TO, about 30% of the PTs recognized the importance of its three subdomains. References varied across subdomains: 68% referred to **promotion of participation**, 65% to **consideration of student learning**, and 49% to **mathematical content**. Category combinations within each subdomain were less common, ranging from 10% to 14%. For instance, 10% of the participants alluded to both categories of **mathematical content**—'challenging tasks' and 'technological resources'—through comments like: *"We should connect real life with maths and explain everyday things in ways students haven't thought about"* and *"We should use ICT tools to make the subject more appealing"* (PT-25). Similarly, 11% referred to both categories of **promotion of participation**—'autonomous participation' and 'collaborative participation'—through items such as *"I want to make classes participatory to engage students"* and *"… organize students into small groups"* (PT-79). Finally, 14% combined 'student critical thinking' and 'adaptive teaching' within **consideration of student learning**. Statements like *"It's important to turn student mistakes into learning opportunities"* highlighted attention to 'student critical thinking', while *"[…] and guide learning to each student"* (PT-67) illustrates 'adaptive teaching'. Overall, these findings show lower percentages of TO category combinations than those observed in PO.

Integrating Professional Orientation and Task Orientation

Table 5 illustrates different levels of integration between PO and TO among PTs, including high PO + partial TO, high PO + minimal TO, partial PO + partial TO, and partial PO + minimal TO. Across all groups, the PTs with a mathematics background outnumbered those with a non-mathematics background, except in the partial PO + partial TO group, where both were equally represented. As shown below, this predominance of mathematics graduates was associated with higher levels of PO than TO. Integrations representing fewer than 5% of PTs were excluded from the results.

High PO + Partial TO

Approximately 8% of PTs (5 with a mathematics degree and 3 with a non-mathematics degree) demonstrated a broad and coherent vision across both domains, referring to the two PO subdomains (**SMK** and **PCK**) and the three TO subdomains (**mathematical content**, **promotion of participation**, and **consideration of student learning**). Most integrated five PO categories and four TO categories.

Within PO, participants alluded to all categories except 'KCC'. This suggests that they recognize the importance of mathematical knowledge at multiple levels, particularly a deep understanding of mathematical ideas, the ability to offer varied explanations, and the capacity to build connections within and beyond the discipline. They also highlighted the relevance of pedagogical knowledge such as mastering different teaching strategies and adapting instruction to student needs. The absence of references to 'KCC' suggests that curriculum knowledge is not perceived as central, reflecting the view of legislation as a prescriptive requirement rather than as a tool for organizing instruction. As several participants noted, this aspect receives limited attention in master's programs. For example, PT-57 explained during the interview: *"We learn about the curriculum as a roadmap for planning lessons, but we rarely focus on designing activities that feel meaningful within the curriculum context"*.

In the TO domain, most PTs referred to four categories: 'technological resources', 'autonomous participation', 'student critical thinking', and 'adaptive teaching', while omitting 'collaborative participation' and 'challenging tasks'. Although they acknowledged the importance of student participation, references to collaborative work remained limited. As PT-66 noted during an interview, *"We were encouraged to get students involved in class, but we didn't get guidance on how to manage small-group work"*. Participants also reported having learned methodologies such as project-based and inquiry-based learning; however, this knowledge appeared largely theoretical, with limited opportunities to design cognitively demanding tasks. According to the interviews, they were rarely asked to design or implement such tasks during their training. As PT-62 reported: *"We learned about project-based learning and spent time on assessments, but we didn't really get to design projects in class, partly because there were so many other subjects to cover"*. Overall, this group demonstrated strong theoretical knowledge with multiple connections to classroom practice.

Partial PO + Partial TO

Approximately 26% of PTs, with a balanced representation of mathematics and non-mathematics backgrounds, showed partial integration of both PO and TO, referring to three to four categories within each domain; most mentioned four PO and four TO categories. Within PO, most PTs referred to all categories except 'KCC' and 'SCK'. As in the first group, 'KCC' was absent, while the lack of references to 'SCK' suggests difficulties mobilizing mathematical knowledge for teaching purposes, such as interpreting or offering multiple solution strategies. Several PTs noted that, although their degree covered advanced mathematics, it did not address school-level content from a teaching perspective. PT-74 explained during the interview: *"In the maths degree, we studied a lot of theory, but not different ways of explaining or solving school maths problems"*. Their reflections are consistent with the structure of the Spanish consecutive teacher education model, which prioritizes disciplinary training over pedagogical preparation. Regarding TO, and consistent with the first group, these PTs referred to all categories except 'collaborative participation' and 'challenging tasks'. Overall, this group showed a relatively balanced integration with several connections between theoretical knowledge and classroom practice.

Partial PO + Minimal TO

About 30% of PTs (18 with a mathematics degree and 11 with a non-mathematics degree) showed partial PO and minimal TO integration, referring to three to four PO categories and one to two TO categories; most mentioned four PO and two TO categories. Within PO, they referred to all categories except 'KCC' and 'SCK'. Within TO, references were limited to 'adaptive teaching' and 'autonomous participation'. Beyond the two categories already absent in the previous group ('collaborative participation' and 'challenging tasks'), they also omitted 'student critical thinking' and 'technological resources'. The absence of 'student critical thinking' reflects the nature of their training: although common student errors were frequently presented in the master's program, little attention was given to using them to foster students' reasoning, limiting PTs' opportunities to develop strategies to address misconceptions and provide targeted feedback. As PT-37 explained: *"We looked at common mistakes (e.g., in equations) and when they usually happen, but not really at how to use them for teaching"*. Similarly, the absence of references to 'technological resources' may be linked to the preparation received. Although PTs were taught to use GeoGebra and other tools to solve mathematical problems, this training lacked a pedagogical focus. As PT-48 noted: *"… We've been taught GeoGebra, but to solve certain problems, not to take it into the classroom and teach with it"*. Despite their teaching practice period and the pedagogical content addressed in the master's program, their preparation appears insufficient to support the effective integration of mathematical content, participation, technology, and student-centered teaching.

High PO + Minimal TO

Approximately 11% of the PTs (8 with a mathematics degree and 3 with a non-mathematics degree) showed the greatest imbalance between the PO and TO domains. These participants achieved a high level in PO but remained at an early stage in translating knowledge into instructional decisions. Interview data suggested that this pattern is associated with low satisfaction with the master's program and limited perceived learning. For example, PT-41 stated: *"For me, the master's program—especially the more general part—wasn't very useful, and even the maths part didn't seem very helpful"*. Unlike the previous group, which had begun to connect some TO categories with theoretical preparation, this group showed no progression toward TO. Their reflections remained largely theoretical, centered on mathematical and pedagogical knowledge, with limited attention to how this translates into classroom practice. They appeared to operate with a general notion of supporting students' learning, without connecting it to the specific demands of mathematics teaching.

DISCUSSION

This study examined how PTs conceptualize PO and TO, and the extent to which both domains are integrated in their reflections on effective mathematics teaching. The findings reveal a greater emphasis on PO than TO across most participant groups, suggesting that PTs' reflections are more closely linked to what teachers should know than to how this knowledge is applied in classroom practice. In this respect, the study aligns with Nickel and Zimmer (2018), who also found a predominance of PO among prospective teachers trained within consecutive models, whereas studies such as Lamote and Engels (2010) and Nickel and Crosby (2021) reported a stronger orientation towards TO. Accordingly, PO may represent a necessary but insufficient condition for the development of TO, as theoretical knowledge does not automatically translate into effective instructional practice. These findings thus highlight a key challenge in initial teacher education: connecting advanced mathematical and pedagogical knowledge with classroom practice.

Concerning PO, PTs referred to most categories, with weaker references to 'SCK' and 'HCK' within the **SMK** subdomain. This indicates that PTs place less emphasis on the importance of mathematical knowledge for aspects like understanding different problem-solving strategies and establishing connections within and beyond mathematics, as already reported by Newton et al. (2022) and Sapkota (2025). In our study, this pattern appears related to the limited opportunities PTs received during their training period. Similarly, 'KCC', within **PCK,** appeared less frequently and was often experienced as prescriptive rather than as a useful tool for teaching, consistent with Kuennen and Beam (2020) and Stylianides and Stylianides (2023). Regarding TO, scarce references to 'collaborative participation' and 'challenging tasks' were identified within the **promotion of participation** and **mathematical content** subdomains, respectively. The limited presence of these categories is particularly concerning, given their importance for fostering mathematical reasoning and moving beyond predominantly procedural instruction, especially in a competency-based curriculum (Alvidrez et al., 2024; Ingram et al., 2020; Sullivan et al., 2015). The limited reference to these categories appears linked to reduced engagement in practice-based activities during their master's program, such as implementing collaborative work and designing cognitively demanding tasks, as also reported by Sullivan et al. (2015). In the case of technological resources, the challenge lies not in their use but in their pedagogical integration. In line with Tefera et al. (2021), this pattern is associated with the structure of consecutive teacher education models.

Different levels of PO and TO integration were identified, including high PO + partial TO, high PO + minimal TO, partial PO + partial TO, and partial PO + minimal TO. The highest levels of integration were observed in the high PO + partial TO and partial PO + partial TO groups. Only one third of the participants demonstrated a broad vision of effective mathematics teaching, connecting solid theoretical foundations with classroom practice. The remaining groups showed limited connections between both domains, suggesting that PTs' conceptions of effective teaching remain largely theory-oriented, with less attention to how knowledge is enacted in practice. Across groups, variations in the number of integrated categories were observed, with PO frequently predominating over TO. This imbalance was more pronounced in groups mostly composed of PTs with a mathematics background, reflecting the strong disciplinary emphasis of consecutive teacher education models, as suggested by Nickel and Zimmer (2018). Studies conducted within concurrent models, such as those by Lamote and Engels (2010) in Belgium and Wong and Liu (2022) in Singapore, reported a more explicit integration of mathematical and pedagogical knowledge with teaching practice.

CONCLUSION

This study sheds light on the ways PTs connect PO and TO in their conceptions of effective mathematics teaching. All participants referred to the PO domain, whereas fewer considered TO. Their reflections highlighted several aspects that should be strengthened in initial teacher education programs, particularly within competency-based curricula: specialized mathematical knowledge, connections between curriculum knowledge and instructional design, and the implementation of cognitively demanding tasks involving collaborative work. Regarding the integration of PO and TO, a clear predominance of PO over TO was observed, especially among PTs with a mathematics background, suggesting that PTs place greater emphasis on mathematical and pedagogical knowledge than on its application in classroom practice. Although some PTs demonstrated connections between both domains, integration was generally uneven and limited.

The findings suggest that stronger connections between knowledge and classroom practice could be fostered within the Spanish consecutive teacher education model. In this regard, concurrent models may offer a more integrated approach to teacher preparation. Although a transition toward a concurrent model in Spain would require structural changes, several actions could still be implemented within the current master's program. The teaching practice period at schools could be complemented with systematic microteaching sessions integrated into master's coursework, in which PTs rehearse instructional decisions such as designing challenging tasks, facilitating collaborative learning, using technological resources pedagogically, or adapting instruction to students' needs in front of trainers and peers, while receiving immediate feedback. Such experiences may help bridge the gap between theoretical knowledge and classroom practice.

This study has several limitations. Although representative of the Spanish context, the sample was limited in size and scope. The research focused on PTs enrolled in a consecutive teacher education model, which may limit the transferability of the findings to other educational contexts. In addition, the qualitative nature of the analysis may have introduced interpretative bias, despite efforts to ensure reliability. Future research could further compare PO and TO integration across different teacher education models, particularly concurrent and consecutive programs, and explore how these orientations evolve during the first years of teaching. Incorporating classroom enactments, simulations, or lesson observations could also provide a deeper understanding of how PTs' orientations are reflected in practice.

Author contributions: MSS-P, JMD-M, JMC-S, & MMR-S: conceptualization, formal analysis, investigation, methodology, writing – original draft, writing – review & editing. All authors agreed with the results and conclusions.

Funding: This study has been funded by the Ministry of Science and Education, Spain, PID2022-139703NB-I00, and by the R&D&I project Grant PID2021-122326OB-I00 funded by MCIN/AEI/10.13039/501100011033. María Soledad Salomón-Plata was a PhD student under the supervision of Professors Diego-Mantecón, Chamoso-Sánchez, and Rodríguez-Sánchez during the preparation of this article.

Ethical statement: The authors stated that this study does not require any ethical approval. The study did not involve human or animal subjects, clinical procedures, or personally identifiable data. The research relied solely on anonymous survey responses and with prior consent from the participants.

AI statement: The authors stated that generative AI was not used in the writing of this article.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Albay, A., & Cetin, H. (2023). A mixed method research study on pre-service primary school teachers' mathematical disposition. *Journal on Mathematics Education, 14*(2), 311-338. https://doi.org/10.22342/jme.v14i2.pp311-338

Albert, M. J., Blázquez-Merino, M., López-Rey, A., & Castro, M. (2021). Influence of technological resources on the development of mathematical competence in high school. *IT Professional, 23*(2), 19-25. https://doi.org/10.1109/MITP.2021.3062685

Almeida, R., & Pietropaolo, R. C. (2022). Early-career mathematics teachers' knowledge in the multiplicative conceptual field. *Acta Scientiae, 24*(2), 179-211. https://doi.org/10.17648/acta.scientiae.6737

Alvidrez, M., Louie, N., & Tchoshanov, M. (2024). From mistakes, we learn? Mathematics teachers' epistemological and positional framing of mistakes. *Journal of Mathematics Teacher Education, 27*, 111-136. https://doi.org/10.1007/s10857-022-09553-4

Arnal-Bailera, A., & Oller-Marcén, A. M. (2020). Prospective secondary mathematics teachers read Clairaut: Professional knowledge and original sources. *Educational Studies in Mathematics, 105*, 237-259. https://doi.org/10.1007/s10649-020-09988-7

Azcárraga, J. A. (2022). La nueva legislación educativa: Por qué no mejorará la educación pública en España [The new education legislation: Why it won't improve public education in Spain]. *Revista Española de Pedagogía, 80*(281), 117-135. https://doi.org/10.22550/REP80-1-2022-08

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389-407. https://doi.org/10.1177/0022487108324554

Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and Teacher Education, 20*(2), 107-128. https://doi.org/10.1016/j.tate.2003.07.001

Bonesrønning, H., Finseraas, H., Hardoy, I., Vaag Iversen, J. M., Nyhus, O. H., Opheim, V., Vea Salvanes, K., Jorde Sandsør, A. M., & Schøne, P.

(2022). Small-group instruction to improve student performance in mathematics in early grades: Results from a randomized field experiment. *Journal of Public Economics, 216*, Article 104765. https://doi.org/10.1016/j.jpubeco.2022.104765

Boström, E., & Palm, T. (2023). The effect of a formative assessment practice on student achievement in mathematics. *Frontiers in Education, 8*. https://doi.org/10.3389/feduc.2023.1101192

Campbell, T. G., & Hodges, T. S. (2020). Using positioning theory to examine how students collaborate in groups in mathematics. *International Journal of Educational Research, 103*, Article 101632. https://doi.org/10.1016/j.ijer.2020.101632

Chamoso, J. M., & Cáceres, M. J. (2009). Analysis of the reflections of student-teachers of mathematics when working with learning portfolios in Spanish university classrooms. *Teaching and Teacher Education, 25*(1), 198-206. https://doi.org/10.1016/j.tate.2008.09.007

Contreras, P. (2016). *Estudio sobre la identidad y conocimiento profesional de estudiantes para maestro de primaria desde la educación matemática* [Study on the identity and professional knowledge of students for primary teacher from the perspective of mathematics education] [PhD thesis, Universidad de Alicante].

Dresel, M., Daumiller, M., Spear, J., Janke, S., Dickhäuser, O., & Steuer, G. (2025). Learning from errors in mathematics classrooms: Development over 2 years in dependence of perceived error climate. *British Journal of Educational Psychology, 95*(1), 180-196. https://doi.org/10.1111/bjep.12697

Du, W., Wijaya, T. T., Cao, Y., & Li, X. (2025). What factors influence secondary students' active participation in mathematics classrooms: A theory of planned behavior perspective. *Acta Psychologica, 253*, Article 104694. https://doi.org/10.1016/j.actpsy.2025.104694

Falcón-Linares, C. (2021). Cómo formar al profesorado de secundaria para satisfacer las necesidades educativas de la próxima década [How to train secondary school teachers to meet the educational needs of the next decade]. *Estudios Pedagógicos (Valdivia), 47*(2), 215-229. https://doi.org/10.4067/S0718-07052021000200215

Flores, M. A., & Day, C. (2006). Contexts which shape and reshape new teachers' identities: A multi-perspective study. *Teaching and Teacher Education, 22*(2), 219-232. https://doi.org/10.1016/j.tate.2005.09.002

Francome, T., & Hewitt, D. (2018). "My math lessons are all about learning from your mistakes": How mixed-attainment mathematics grouping affects the way students experience mathematics. *Educational Review, 72*(4), 475-494. https://doi.org/10.1080/00131911.2018.1513908

Gardesten, M., & Palmér, H. (2023). Students' participation in mathematics in inclusive classrooms: A study of the enacted mathematical and relational knowing of teachers. *Mathematical Thinking and Learning, 27*(2), 157-177. https://doi.org/10.1080/10986065.2023.2258485

Hwang, G. J., Sung, H. Y., Chang, S. C., & Huang, X. C. (2020). A fuzzy expert system-based adaptive learning approach to improving students' learning performances by considering affective and cognitive factors. *Computers and Education: Artificial Intelligence, 1*, Article 100003. https://doi.org/10.1016/j.caeai.2020.100003

Ingram, N., Holmes, M., Linsell, C., Livy, S., McCormick, M., & Sullivan, P. (2020). Exploring an innovative approach to teaching mathematics through the use of challenging tasks: A New Zealand perspective. *Mathematics Education Research Journal, 32*, 497-522. https://doi.org/10.1007/s13394-019-00266-1

Iturbe-Sarunić, C., & Silva-Hormazábal, M. (2022). Desarrollo de una propuesta de integración de matemática y ciencias naturales en la formación inicial docente [Development of a proposal for the integration of mathematics and natural sciences in initial teacher training]. *Estudios Pedagógicos (Valdivia), 48*(3), 255-279. https://doi.org/10.4067/S0718-07052022000300255

Kuennen, E. W., & Beam, J. E. (2020). Teaching the mathematics that teachers need to know: Classroom ideas for supporting prospective elementary teachers' development of mathematical knowledge for teaching. *The Mathematics Enthusiast, 17*(2), 771-805. https://doi.org/10.54870/1551-3440.1503

Kyaruzi, F., Strijbos, J. W., & Ufer, S. (2020). Impact of a short-term professional development teacher training on students' perceptions and use of errors in mathematics learning. *Frontiers in Education, 5*. https://doi.org/10.3389/feduc.2020.559122

Lamote, C., & Engels, N. (2010). The development of student teachers' professional identity. *European Journal of Teacher Education, 33*(1), 3-18. https://doi.org/10.1080/02619760903457735

Li, H. C., & Stylianides, A. J. (2018). An examination of the roles of the teacher and students during a problem-based learning intervention: Lessons learned from a study in a Taiwanese primary mathematics classroom. *Interactive Learning Environments, 26*(1), 106-117. https://doi.org/10.1080/10494820.2017.1283333

Li, J., & Hu, Q. (2024). Influence of different types of interclass ability grouping on students' academic achievement in mathematics: Evidence from the Confucian Asian cluster. *Educational Studies, 51*(5), 1150-1169. https://doi.org/10.1080/03055698.2024.2415609

LOMLOE. (2020). Ley orgánica 3/2020, de 29 de diciembre, por la que se modifica la ley orgánica 2/2006, de 3 de mayo, de educación [Organic law 3/2020, of December 29, amending organic law 2/2006, of May 3, on education]. *Boletín Oficial del Estado*, (340). https://www.boe.es/eli/es/lo/2020/12/29/3

López Rupérez, F. (2022). El enfoque del currículo por competencias. Un análisis de la LOMLOE [The competency-based curriculum approach. An analysis of the LOMLOE]. *Revista Española de Pedagogía, 80*(281), 161-174. https://doi.org/10.22550/REP80-1-2022-05

Lorenzo-Vicente, J. A., Muñoz-Galiano, I. M., & Beas-Miranda, M. (2015). Models of initial training of secondary school teachers in Spain from a European perspective. *Revista Complutense de Educación, 26*(3), 741-757. https://doi.org/10.5209/rev_RCED.2015.v26.n3.44866

Meyer, D., Doll, J., & Kaiser, G. (2023). Professional identity of pre-service teachers: Actual and designated identity profiles and their relationship to teacher education programs. *Frontiers in Education, 8*. https://doi.org/10.3389/feduc.2023.1134848

Muñiz-Rodríguez, L., Aguilar-González, Á., & Rodríguez-Muñiz, L. J. (2020). Perfiles del futuro profesorado de matemáticas a partir de sus competencias profesionales [Profiles of future mathematics teachers based on their professional skills]. *Enseñanza de las Ciencias, 38*(2), 141-161. https://doi.org/10.5565/rev/ensciencias.3161

Nascimento, F. J. D., Castro, E. R., Leite, L. R., & Lima, M. S. L. (2021). Dialogue as a constitutive experience in the initial training of mathematics teachers. *Praxis Educativa, 16*, 1-14. https://doi.org/10.5212/PraxEduc.v.16.16556.052

Newton, J., Alvey, C., & Hudson, R. (2022). Investigating mathematics pre-service teachers' knowledge for teaching: Focus on quadratic equations. *Mathematics Teacher Education and Development, 24*(2), 86-110.

Nickel, J., & Crosby, S. (2021). Professional identity values and tensions for early career teachers. *Teaching Education, 33*(3), 317-331. https://doi.org/10.1080/10476210.2021.1895107

Nickel, J., & Zimmer, J. (2018). Professional identity in graduating teacher candidates. *Teaching Education, 30*(2), 145-159. https://doi.org/10.1080/10476210.2018.1454898

Nicmanis, M. (2024). Reflexive content analysis: An approach to qualitative data analysis, reduction, and description. *International Journal of Qualitative Methods, 23*. https://doi.org/10.1177/16094069241236603

OECD. (2019). The OECD learning compass 2030. OECD future of education and skills 2030. *OECD*. https://www.oecd.org/education/2030-project/contact/OECD_Learning_Compass_2030_Concept_Note_Series.pdf

Oviedo, A. F., & Lizárraga, A. (2022). Revisión de la literatura sobre evaluación de la formación continua de docentes en matemáticas [Literature review on the evaluation of continuing professional development for mathematics teachers]. *Educación Matemática, 34*(1), 131-156. https://doi.org/10.24844/EM3401.05

Pérez, E., Serrano, R., Pontes, A., & Carpio, A. J. (2021). Teachers' professional identity: Validation of an assessment instrument for preservice teachers. *Heliyon, 7*(9), Article e08049. https://doi.org/10.1016/j.heliyon.2021.e08049

Pincheira, N., & Alsina, Á. (2021). Teachers' mathematics knowledge for teaching early algebra: A systematic review from the MKT perspective. *Mathematics, 9*(20), Article 2590. https://doi.org/10.3390/math9202590

Prast, E. J., Hickendorff, M., & Van de Weijer-Bergsma, E. (2025). High-achieving students in mathematics: A heterogeneous group. *Learning and Individual Differences, 119*, Article 102629. https://doi.org/10.1016/j.lindif.2025.102629

Prendes, M. P., Montiel, F. J., & González, V. (2021). Uso de TIC por parte del profesorado de enseñanza secundaria analizado a partir del modelo de ecologías de aprendizaje: Estudio de caso en la Región de Murcia [Use of ICT by secondary school teachers analyzed from the learning ecologies model: A case study in the Murcia Region]. *Publicaciones, 51*(3), 109-135. https://doi.org/10.30827/publicaciones.v51i3.18374

Rodríguez-Alveal, F., Vásquez, C., & Rojas, F. (2019). Formación inicial docente en profesores de matemática: Una mirada desde la evaluación nacional diagnóstica [Initial teacher training for mathematics teachers: A look from the national diagnostic assessment]. *Estudios Pedagógicos (Valdivia), 45*(2), 141-153. https://doi.org/10.4067/S0718-07052019000200141

Rohmah, I. I. T., Faridi, A., Saleh, M., & Fitriati, S. W. (2019). Content and language integrated learning (CLIL): Teachers' point of view. In *Proceedings of the 2nd International Conference on Education* (pp.

594-600). https://doi.org/10.4108/eai.28-9-2019.2291094

Ruiz, N., Chandía, E., Rojas, D., Baeza, M., & Reyes, C. (2023). Perfiles de conocimiento matemático de estudiantes de pedagogía en educación básica para enseñar geometría [Mathematical knowledge profiles of students of pedagogy in basic education to teach geometry]. *Estudios Pedagógicos (Valdivia), 49*(1), 255-280. https://doi.org/10.4067/S0718-07052023000100255

Sachdeva, S., & Eggen, P. O. (2021). Learners' critical thinking about learning mathematics. *International Electronic Journal of Mathematics Education, 16*(3), Article em0644. https://doi.org/10.29333/iejme/11003

Sapkota, B. (2025). Secondary preservice teachers' mathematical knowledge for teaching: Affordances and limitations of peer teaching and reflection. *International Journal of Science and Mathematics Education, 23*, 2349-2373. https://doi.org/10.1007/s10763-025-10555-w

Sevillano, V., & Sánchez, E. (2021). El camino hacia la carrera docente en España. Los secretos del éxito de la formación del profesorado en Finlandia y Singapur [The path to a teaching career in Spain. The secrets of successful teacher training in Finland and Singapore]. *Revista de la Educación Superior, 50*, 105-128.

Solano-Díaz, S., Conde-Carmona, R., & Padilla-Escorcia, I. (2022). Caracterización del conocimiento tecnológico del contenido (TCK): Un estudio de caso con profesores de matemáticas en formación inicial [Characterization of technological content knowledge (TCK): A case study with pre-service mathematics teachers]. *Educación y Humanismo, 24*(42), 144-162. https://doi.org/10.17081/eduhum.24.42.5142

Spitzer, S. M., & Phelps-Gregory, C. M. (2024). The relationship between prospective teachers' mathematics knowledge for teaching and their ability to notice student thinking. *Mathematics Education Research Journal, 36*, 443-470. https://doi.org/10.1007/s13394-023-00455-z

Stylianides, G. J., & Stylianides, A. J. (2023). Promoting elements of mathematical knowledge for teaching related to the notion of assumptions. *Mathematical Thinking and Learning, 26*(4), 382-410. https://doi.org/10.1080/10986065.2023.2172617

Sullivan, P., Askew, M., Cheeseman, J., Clarke, D., Mornane, A., Roche, A., & Walker, N. (2015). Supporting teachers in structuring mathematics lessons involving challenging tasks. *Journal of Mathematics Teacher Education, 18*(2), 123-140. https://doi.org/10.1007/s10857-014-9279-2

Tefera, A., Atnafu, M., & Michael, K. (2021). The relevance of current ethiopian primary school teacher education program for pre-service mathematics teacher's knowledge and teacher educator's awareness about mathematics knowledge for teaching. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(5), Article em1964. https://doi.org/10.29333/ejmste/10858

Uygun, T. (2020). Pre-service middle level mathematics teachers' noticing of student mathematical thinking and teacher identity in the context of virtual experimentation. *International Journal of Mathematical Education in Science and Technology, 51*(7), 1098-1119. https://doi.org/10.1080/0020739X.2020.1762940

Wafubwa, R. N., & Csíkos, C. (2022). Impact of formative assessment instructional approach on students' mathematics achievement and their metacognitive awareness. *International Journal of Instruction, 15*(2), 119-138. https://doi.org/10.29333/iji.2022.1527a

Wong, C. Y. E., & Liu, W. C. (2022). Evaluating the teacher professional identity of student teachers: Development and validation of the teacher professional identity scale. *Journal of Education, 204*(1), 131-144. https://doi.org/10.1177/00220574221101375

Zhang, S., Chan, M. C. E., Clarke, D., & Cao, Y. (2021). An investigation of student participation in collaborative problem solving in mathematics: Positioning and negotiation among four Chinese students. *Journal of Educational Research in Mathematics, 31*(3), 277-297. https://doi.org/10.29275/jerm.2021.31.3.277

Zuzovsky, R., & Donitsa-Schmidt, S. (2017). Comparing the effectiveness of two models of initial teacher education programmes in Israel: Concurrent vs. consecutive. *European Journal of Teacher Education, 40*(3), 413-431. https://doi.org/10.1080/02619768.2017.1318377