Frontiers in Educational Practice and Research
Vol. 1 (2025), No. 2, pp. 105-119
DOI: https://doi.org/10.55578/fepr.2509.009

ARTICLE

Does the integration of AI-driven robotics into mathematics education serve as a form of reterritorialization of an educator's professional identity?

Samuel Clarke [1,*]

[1] *York St John University, London, the United Kingdom*

[*]Corresponding author. Email: s.clarke1@yorksj.ac.uk

Received: 10 September 2025, Accepted: 24 September 2025, Published: 26 September 2025

Abstract

The integration of AI-driven robotics into mathematics education has emerged as a transformative force, reshaping traditional pedagogical practices and redefining educators' professional identities. Drawing on Deluzian theory, this article explores the concept of reterritorialization within the context of AI technology's incorporation into mathematics teaching. Through a systematic selection of 9 case studies, the article highlights the duality of educators' professional identity (EPI) that educators experience: one that embraces innovative pedagogical methodologies and another that grapples with challenges posed by technological demands. The findings reveal that while AI-driven robotics can enhance student engagement and learning outcomes, they also impose constraints that may lead to feelings of inadequacy among educators.

Keywords: AI-driven Robotics; Mathematics Education; Reterritorialization; Educators' professional Identity (EPI)

1. INTRODUCTION

Since the release of advanced tools such as ChatGPT in late 2022, Artificial Intelligence (AI) has rapidly reshaped educational practice [1,2], including mathematics instruction [3]. AI now offers powerful methods for teaching and learning [4] and is increasingly viewed as capable of augmenting human thinking and supporting mathematical skill development [3,5]. Although definitions of AI vary, most agree it refers to technologies that demonstrate human-level intelligence and operate with a degree of autonomy [6-8].

Against this backdrop, this article examines how AI-driven robotics in mathematics education can redefine educators' professional identities [9-11]. This article argues that such integration creates both opportunities for innovative, engaging instruction and challenges that disrupt traditional roles [11-13], producing a dual professional identity [14-16], one embracing new methodologies and another grappling with the constraints of technological change.

2. RESEARCH AIM, QUESTION AND RATIONALE

This article therefore aims to explore how this tension between innovation and constraint affects educators' practices and sense of identity [17-19]. It seeks to understand how the integration of AI-driven robotics in mathematics education, could theoretically serve as a form of reterritorialization of what it means to be an educator [20-22], and more specifically, a mathematics educator. Through an analysis of systematically selected case studies of previous research in this field, consisting of both the positive transformations in teaching practices and the potential challenges educators face as they adapt to new technologies, this article aims to answer the questions:

1. To what extent does the integration of AI-driven robotics into mathematics education reterritorialize an educator's professional identify?
2. To what extent does this effect fashion a duality of their professional identity?

https://doi.org/10.55578/fepr.2509.009

2.1. Educator Professional Identity

To do so, a foundational understanding of what is meant by the phrase ‘professional identity’ is paramount. Historically, educators’ professional identify has emerged as its own field of research [24,25] with an attempt to define it through a reliance on the concept of ‘identity’ in social science and philosophy [26]. Identity is not static, but a fluid ever-changing state of self-actualisation and understanding [27] which is fundamentally linked to an individual’s social interactions and environment [27]. Our mental manifestation of our ‘self’ or ‘identity’ can be described as our attempt at structured representation of our theories, attitudes and beliefs about ourselves [28] but can arise only in a social setting where there is social communication [29] through a process of interpreting ourselves and being recognised by external others in a given social setting [30].

In western society, one entrenched in neoliberalism ideology [31,32], there has been a trend of educator professional identify (or EPI) as “what works” is “what counts” [14-16,32] concerning how to understand EPI. As pointed out by Dewey [33], this disregards the more reflective element of an educator’s role and negates the complexity of the human aspect of what it means to form EPI [34]. This has led to a collective – though not universal – appreciation that EPI is linked to the perceptions, views, beliefs, emotions, motivations, and attitudes that educators have about their own role [17-19]. EPI is also attributed to the mission and qualities of an individual educator [20-22] which evolve over time through personal and professional experiences within a set cultural context [23].

According to Davey [11], modern understandings of professional identity, drawn from various disciplines and perspectives, share several core assumptions:

(i) it is shaped within multiple contexts that encompass personal, social, and cultural dimensions;

(ii) it is continually evolving, complex, and subject to ongoing renegotiation throughout a person's career;

(iii) it is developed through interpersonal relationships;

(iv) it involves emotional experiences and evaluative judgments.

It is this modern interpretation of EPI as manifestation of a particular ‘professional identity’ (Davey, 2013) that will be held as central to the work that follows in this article.

2.2. Rationale

The new context of education in the AI age [4] necessitates a re-evaluation of educational practices and the roles of educators. This matters because it can be stipulated there is a critical need for educators to navigate the rapidly changing landscape of technology in education [35-37]. Understanding how AI-driven robotics impacts professional identity is essential for developing effective teacher training programs and supporting educators in adapting their pedagogical strategies. It also highlights the importance of ensuring that technological integration does not overwhelm or constrain educators but rather empowers them to enhance student learning and engagement.

3. METHODOLOGY

Employing an interpretivist paradigm [38,39] with an original focus on actively searching for linkages between the integration of AI-driven robotics into mathematics education and the theoretical potential for such an integration to act as a form of reterritorialization [40,41] that redefines or constrains the educator's professional identity, has enabled a meaningful contribution to the wider debate on educator agency in the AI age of education.

3.1. Systematic literature selection

Taking the first step to conduct this analysis, research on available databases (e.g., Springer Nature, Taylor & Francis Ltd, Wiley-Blackwell) was filtered using the PRISMA 2020 flow diagram [42], which can be seen in Figure 1. From this comprehensive search, 9 articles were selected based on criteria of:

- age range <10 years at the time of search
- language (English)
- peer-review status
- academic journal classification
- subject 1: ‘learning’ → subject 2: ‘mathematics education’ → subject 3: ‘robotics’

The decision to include exclusively articles published during or after 2015 is driven by the necessity to concentrate on contemporary literature, thereby ensuring that the analysis captures the latest trends and advancements in the domain of AI-driven robotics into mathematics education. Restricting the selection to publications from this period allows for the incorporation of recent research findings and insights that are pertinent to current educational contexts [43]. Furthermore, limiting the corpus to English-language articles facilitates broader accessibility and aligns with the researcher's linguistic capabilities. Given that English dominates academic publishing, this criterion enables the dissemination of findings to a wider international audience and promotes cross-cultural understanding [44].

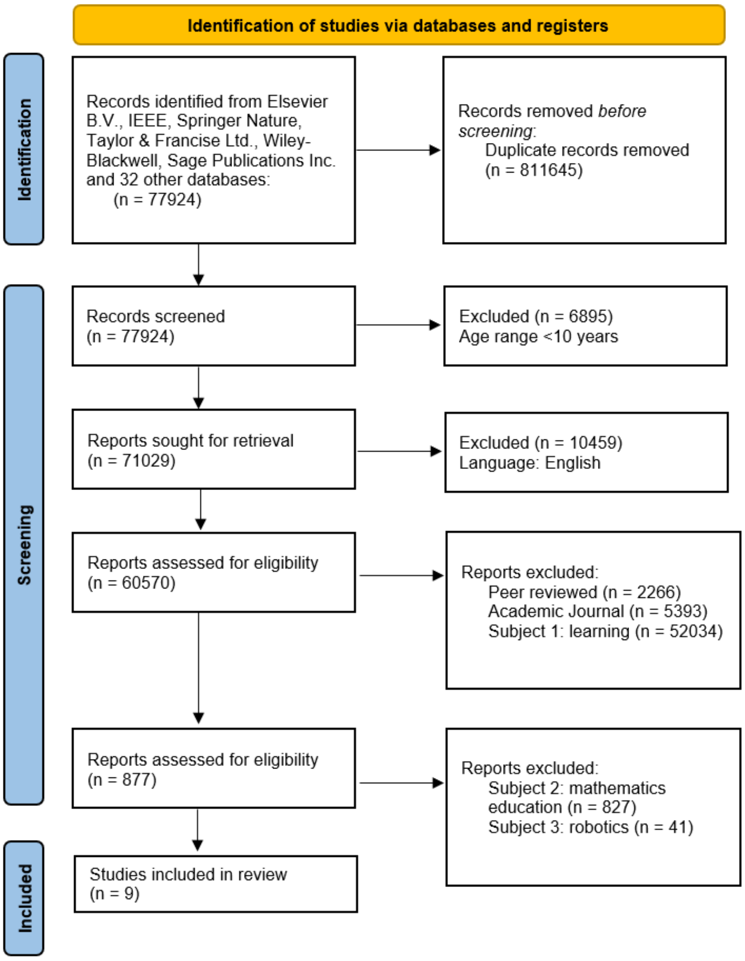

Figure 1. PRISMA 2020 flow diagram [42]

Peer review is a comprehensive process that involves the assessment of research by subject matter experts to verify the validity of the methodology, results, and interpretations. Emphasising peer-reviewed articles ensures that the study upholds rigorous scholarly standards and enhances the credibility and reliability of the findings [45]. Additionally, selecting articles in descending order of relevance, beginning with primary subject matter 'AI in education', followed by subjects of 'learning', then 'mathematics education', and subsequently 'robotics' permits a more focused and in-depth exploration of the topic [46].

3.2. Data analysis, interpretation and reporting

In this review, 9 articles were systematically selected using a PRISMA flowchart (see Figure 1), which guided the identification, screening, and inclusion of relevant literature. These articles were chosen based on predefined inclusion criteria to ensure their relevance and quality. The researcher examined each of the 9 articles, carefully analysing their content to identify recurring ideas, concepts, and patterns relevant to the review's research questions. This involved annotating texts, highlighting significant passages, and taking detailed notes. As part of this process, contextual nuances—such as study settings, populations, and theoretical frameworks—were interpreted to understand how these factors influenced the findings. The researcher organised these observations to uncover common themes, such as frequently discussed topics, methodological approaches, or key findings.

This process was influenced by the researcher's social context, acknowledging that knowledge construction is inherently subjective [47,48]. Throughout the review, the researcher engaged in self-reflexivity [49], critically examining how personal circumstances, experiences, and biases shaped the interpretation of the literature [50,51]. This reflective practice was essential in interpretivist research, facilitating the extraction of both explicit content and underlying meanings in the literature [52], and recognised that understanding is co-constructed between the researcher and the data, thereby highlighting the importance of acknowledging potential biases [50].

4. FORMING CASE STUDIES

In this study, the 9 selected articles which would form "case studies" to support the discussion were:

Case Study	Article
1	Casler-Failing, S. (2021). Learning to teach mathematics with robots: Developing the 'T' in technological pedagogical content knowledge. *Association for Learning Technology,* 29, 1-20
2	Casler-Failing, S. (2018). Robotics and math: using action research to study growth problems. *Canadian Journal of Action Research*, 19 (2), 4-25
3	Lopez-Caudana, E., Ramirez-Montoya, M., Martinez-Perez, S., & Rodriguez-Abitia, G. (2020). Using Robotics to Enhance Active Learning in Mathematics: A Multi-Scenario Study. *Mathematics,* 8 (2163), doi:10.3390/math8122163
4	Seckel, M., Breda, A., Font, V., & Vásquez, C. (2021). Primary School Teachers' Conceptions about the Use of Robotics in Mathematics. *Mathematics*, 9 (3186), https://doi.org/10.3390/math9243186
5	Rico-Bautista, N., Rico-Bautista, D., & Medina-Cárdenas, Y. (2019). Collaborative work as a learning strategy to teach mathematics incorporating robotics using led godt education system and fischertechnik in seventh graders at the school Isidro Caballero Delgado in Floridablanca Santander Colombia. *Journal of Physics: Conference Series*, 1386 (012146), doi:10.1088/1742-6596/1386/1/012146
6	Saez-Lopez, J-M., Sevillano-Garcia, M-L., & Vazquez-Cano, E. (2019). The effect of programming on primary school students' mathematical and scientific understanding: educational use of mBot. *Education Technology Research Development*, 67, 1405–1425, https://doi.org/10.1007/s11423-019-09648-5
7	Francis, K., & Davis, B. (2018). Coding Robots as a Source of Instantiations for Arithmetic. *Digital Experiences in Mathematics Education*, 4, 71–86, https://doi.org/10.1007/s40751-018-0042-7
8	Forsström, S., & Afdal, G. (2020). Learning Mathematics Through Activities with Robots. *Digital Experiences in Mathematics Education,* 6, 30–50. https://doi.org/10.1007/s40751-019-00057-0
9	Harper, F., Stumbo, Z., & Kim, N. (2021). When robots invade the neighbourhood: Learning to teach preK-5 mathematics leveraging both technology and community knowledge. *Contemporary Issues in Technology and Teacher Education, 21*(1), 19-52.

The formation of the case studies (see Figure 2) began with the identification of key elements from the selected academic article. Critical terminology and phrases were extracted to encapsulate core concepts and findings, focusing on:

- Article Focus & Research Questions
- Educational Contexts & Participants
- Main Themes
- Summary of Key Findings
- The Role of the Educator
- Implications & Reflections

Patterns and trends across multiple articles were noted to highlight emerging practices and common challenges within the field. Structuring the case studies (Figure 2) involved organising content into sections including an introduction that outlined the article's focus and research questions, a description of the educational context and participant demographics, and details on how AI-driven robotics was integrated into the mathematics curriculum through specific tools and instructional strategies.

Figure 2. AI-driven robotics in mathematics education case studies.

Case Study	Article Focus & Research Questions	Educational Contexts & Participants	Main Themes	Summary of Key Findings	The Role of the Educator	Implications & Reflections
1	The article investigates how Lego robotics instruction, integrated into a middle grades mathematics methods course, informs pre-service teachers' (PSTs) technological pedagogical content knowledge (TPACK) through the lens of Social Constructivist Theory. The main research question is: "How does the incorporation of Lego robotics instruction in a middle grades mathematics methods course inform pre-service teachers' TPACK regarding the robotics?"	The study was conducted at a large university in the southeastern United States within a mathematics methods course for middle grades certification. Five PSTs (three females and two males) participated, representing a range of experiences and perspectives. They were either in their junior or senior year, with varying backgrounds in robotics and coding.	- Improvement of TPACK through hands-on robotics instruction - The importance of collaboration and social learning (Vygotsky's theory) - Robotics as a tool for enhancing mathematical understanding and engagement - The need for in-depth technology training in teacher education - The role of frustration and perseverance in learning	The integration of Lego robotics into the methods course positively influenced PSTs' TPACK, enhancing their understanding of how to use robotics as an instructional tool. All PSTs reported improved skills in building and programming robots and recognized the potential of robotics to promote student engagement and understanding in mathematics. Collaboration among PSTs was crucial to their success.	The educator facilitated a hands-on, constructivist learning environment by providing instruction on robotics, scaffolding students' understanding through questioning, and encouraging collaboration. The educator's role also included modelling effective pedagogical approaches to integrating technology into mathematics instruction.	The findings suggest that integrating specific technologies like robotics in teacher preparation courses can enhance PSTs' ability to teach with technology effectively. It highlights the importance of sustained exposure to technology and collaborative learning experiences. The research indicates a need for ongoing professional development in technology integration for future educators to support their evolving professional identities.
2	The article investigates the effects of incorporating LEGO robotics into a seventh-grade mathematics curriculum, focusing on developing proportional reasoning. The research questions are: (1) In what ways do students reason while solving growth problems with the LEGO robots? (2) How does the incorporation of LEGO robotics influence students' proportional reasoning?	The research was conducted in a small, independent Pre-K through eighth-grade school in upstate New York. The participants were six seventh-grade students (four females and two males) during the 2016-2017 school year. The class was diverse in socioeconomic makeup, and students worked in heterogeneous pairs.	- Proportional reasoning as a crucial mathematical skill - The role of collaboration and discussion in learning - Social Constructivist Theory as a framework for understanding learning - The importance of hands-on, engaging learning experiences through robotics - The integration of technology in education	The study found that incorporating LEGO robotics into the curriculum positively influenced students' proportional reasoning skills. Students engaged in problem-solving through collaborative discussions, utilized quantitative reasoning, and experienced growth in understanding proportional relationships. The robotics context facilitated meaningful discourse.	The educator acted as a facilitator, guiding students in their learning process, prompting discussions, and encouraging collaboration among peers. The educator's role was crucial in creating a supportive environment where students could explore proportional reasoning through hands-on activities with robots.	The findings suggest that integrating robotics in mathematics education can enhance students' understanding and engagement. However, the study highlights the need for further research to generalize findings due to the small sample size. The educator's professional identity may evolve as they adapt to using technology in teaching, potentially reshaping instructional practices and engagement strategies.

Case Study	Article Focus & Research Questions	Educational Contexts & Participants	Main Themes	Summary of Key Findings	The Role of the Educator	Implications & Reflections
3	The article investigates how the integration of robotics in mathematics education enhances active learning strategies. The primary research question is: “What are the conditions that promote effective active math learning with robotic support?” The study aims to identify key conditions that contribute to successful learning outcomes facilitated by technology.	The study was conducted across three educational levels: elementary, secondary, and high school. Participants included students and teachers from each level, with specific interventions designed for groups in each context (e.g., 3rd and 5th graders in elementary, secondary school students in analytical geometry, and high school students in trigonometry). The total number of participants included 65 elementary students, 50 secondary students, and 140 high school students.	- The role of technology in enhancing student motivation and attention - Active learning strategies facilitated by robotics - The importance of teacher training and involvement - The conditions for effective learning (level of education, student motivation, and teacher preparation).	The research found that: 1) integrating robotics positively impacts student motivation and engagement in mathematics, 2) effective learning is contingent on the educational level of students and the training teachers receive, 3) students exhibited improved performance in mathematics when robotics were used, and 4) the role of the teacher is critical in planning and implementing technology-enhanced learning experiences.	Educators are portrayed as facilitators who must adapt to the integration of technology into their teaching practices. Their professional identity evolves as they engage with robotics, requiring them to be trained in using these tools effectively. Educators also play a vital role in designing learning activities that leverage technology to enhance student learning and adapt to the dynamics of technology-rich classrooms.	The study highlights the potential for robotics to transform mathematics education, suggesting that educators must embrace new technologies to remain relevant. There are implications for teacher training programs to include robotics and technology integration. Reflectively, the findings indicate that while technology can enhance learning, careful consideration of its implementation is necessary to avoid overwhelming educators and students alike.
4	The article focuses on primary school teachers' conceptions regarding the use of robotics in mathematics education. It seeks to answer the research question: "Which are the conceptions that primary school teachers have regarding the use of educational robots in the process of teaching and learning mathematics?" This inquiry is relevant in the context of Chilean initiatives to introduce Computational Thinking into the curriculum.	The study was conducted in two districts in Chile, involving 83 primary school teachers (74 women and 9 men) who teach First to Fourth grades. Participants varied in academic qualifications, including postgraduate degrees in mathematics and robotics training. The sample was selected through a probabilistic two-stage cluster sampling method.	- Teachers' positive predisposition towards using robotics in mathematics education - Challenges faced in implementation due to classroom constraints (e.g., large class sizes and limited space) - The significance of teachers' conceptions in shaping pedagogical practices - The role of didactic suitability criteria in evaluating teaching processes.	The findings indicate that teachers generally have positive conceptions regarding the integration of robots into mathematics teaching and learning. However, perceptions varied among different clusters of teachers based on their experience and academic training. The mediational didactic suitability criterion was identified as a significant challenge, with teachers expressing concerns about classroom management and space limitations.	Educators play a crucial role in the integration of robotics into mathematics education. Their conceptions influence pedagogical approaches, and they must navigate challenges related to classroom dynamics and the adequacy of resources. The study highlights the need for ongoing professional development to equip teachers with the skills and confidence to effectively incorporate robotics into their teaching practices.	The research underscores the complexity of integrating AI-driven robotics into mathematics education and its potential impact on teachers' professional identities. It suggests that while robotics may enhance learning experiences, the associated challenges can constrain educators' practices and reshape their identities. The study calls for targeted professional development and a re-evaluation of support structures to facilitate effective integration.

Case Study	Article Focus & Research Questions	Educational Contexts & Participants	Main Themes	Summary of Key Findings	The Role of the Educator	Implications & Reflections
5	The article examines the impact of collaborative work in mathematics education, incorporating robotics via the LEGO® education system and Fischertechnik for seventh graders in a school in Floridablanca, Colombia. The research questions focus on whether the use of robotics enhances information exchange among students, promotes organized teamwork, encourages responsibility in achieving group goals, improves critical analysis of mathematical problems, and fosters cognitive knowledge and collaborative skills.	The study was conducted at Isidro Caballero Delgado School in Floridablanca, Santander, Colombia, involving 70 seventh-grade students. The participants included students from various socioeconomic backgrounds facing challenges such as economic instability and social issues like drug problems. The educational context involved implementing innovative teaching strategies in a traditional classroom environment to foster engagement and understanding in mathematical concepts through robotics.	- Collaborative Learning: Emphasizes the benefits of cooperative strategies in education. - Robotics in Education: Explores how integrating robotics can enhance mathematical understanding. - Student Engagement: Highlights the importance of active participation and motivation among students. - Social and Cognitive Skills Development: Focuses on the enhancement of interpersonal abilities and critical thinking through collaborative projects.	- The integration of robotics led to increased student interest and motivation, particularly among those with learning disabilities. - Students actively engaged in problem-solving and critical analysis of mathematical concepts through the assembly of prototypes. - There was a significant improvement in social interaction and collaboration among students, with 80.95% showing interest in working in groups. - Performance indicators showed a positive trend in academic achievement, with a notable increase in students scoring between 80-100 in assessments. - Parents reported a shift in attitude towards mathematics and increased involvement in their children's academic processes.	Educators facilitated the learning process by designing workshops, assigning roles within collaborative groups, and providing guidance during the assembly of robotics prototypes. They played a crucial role in creating a dynamic learning environment that encouraged student participation and critical thinking. Professional development for teachers was emphasized to keep them updated with innovative teaching practices and to reflect on their pedagogical approaches.	The findings suggest that integrating AI-driven robotics into mathematics education can significantly enhance student engagement and learning outcomes. However, it also raises questions about the evolving role of educators in this new context. The necessity for teachers to adapt and innovate their teaching strategies may redefine their professional identity, potentially constraining traditional roles while also offering new avenues for collaboration and creativity in teaching. Further research is encouraged to explore how such integrations could influence educational practices and teacher professional development in various contexts.
6	The article focuses on the integration of programming and robotics, specifically using mBot, into primary school education to enhance mathematical and scientific understanding. Research questions include: 1. Are there significant improvements in students' academic results in	The study was conducted in four primary education schools in Spain, involving 93 sixth-grade students (ages approximately 11-12). The participants were divided into an experimental group (using robotics and programming) and a control	- Integration of robotics and programming in education. - Active methodologies and student-centred learning. - Development of computational thinking and logical skills.	- Significant improvements were noted in mathematics scores in the experimental group, with a p-value of 0.000 indicating strong statistical significance. - No significant improvement was found in science scores. - Positive changes in	Educators facilitated the integration of robotics and programming, guiding students in active learning environments. They were crucial in designing and implementing the curriculum that emphasized hands-on experiences and collaborative problem-	The study implies that integrating robotics and programming can significantly enhance students' mathematical understanding and engagement. However, the lack of improvement in science suggests a need for further exploration in that area. Educators must navigate the

Case Study	Article Focus & Research Questions	Educational Contexts & Participants	Main Themes	Summary of Key Findings	The Role of the Educator	Implications & Reflections
	math and science with the application of programming and robotics? 2. Do programming and robotics enable active methods, motivation, critical thinking skills, and problem-solving?	group (traditional teaching methods).	- Impact of technology on student engagement and academic performance.	students' understanding of computational concepts and enhanced motivation, commitment, and participation were reported.	solving. The study suggests that educators need to adapt to new methodologies and technologies while maintaining pedagogical effectiveness.	evolving landscape of technology in education and consider how these tools redefine their professional identity and teaching practices. Further research is recommended to address the barriers in implementing such technologies in other subjects.
7	The article investigates the integration of coding and robotics (specifically Lego Mindstorms EV3) into mathematics education, exploring the potential connections between programming and mathematical understanding. The research questions revolve around how programming robots may support children's understanding of number and arithmetic, particularly transitioning from additive to multiplicative thinking.	The study took place over four half-day sessions at Pakan School, Whitefish Lake First Nation 128, in rural Northern Alberta. Participants included 22 children aged 9 to 10 years who engaged in building and programming robots. The sessions involved practical tasks that aimed to integrate coding with mathematical concepts within the existing curriculum.	- Embodied Cognition: The study emphasizes the role of physical engagement and metaphor in understanding mathematical concepts. - Instantiations of Arithmetic: Explores how different metaphors (e.g., object collection, measuring stick) are represented in programming tasks. - Transition from Additive to Multiplicative Thinking: Investigates how coding can facilitate this transition through practical applications in programming.	The findings suggest that engaging children in programming tasks can significantly support their understanding of numbers and arithmetic. Practical tasks encourage children to move from additive to multiplicative thinking. The study highlights the importance of metaphorical understanding in mathematics and demonstrates that programming robots provides opportunities for deeper mathematical engagement.	Educators play a crucial role in facilitating the connection between programming and mathematical concepts. They are responsible for guiding students in recognizing and employing appropriate metaphors for understanding number. The educator's interaction, feedback, and ability to prompt students toward mathematical thinking are vital for fostering a productive learning environment.	The integration of robotics and coding into mathematics education can redefine the educator's role, emphasizing the need for a pedagogical shift that values computational thinking alongside traditional mathematics. This reterritorialization may challenge existing professional identities, as educators adapt to new methods of teaching that incorporate technology. The study suggests further research on how these changes influence both teaching practices and the understanding of mathematical concepts.

Case Study	Article Focus & Research Questions	Educational Contexts & Participants	Main Themes	Summary of Key Findings	The Role of the Educator	Implications & Reflections
8	The article focuses on the integration of programming and robotics into mathematics education, specifically examining the use of mathematical tools in robot-based, problem-solving activities. The primary research question is: What is the relationship between mathematical tools and objects in robot-based, collective student learning activities in secondary education?	The research was conducted in a secondary school in Norway, involving students aged 12-13 in an elective class called Technology in Practice. The study observed groups of two or three students working with Lego Mindstorm robots over an eight-week period, focusing on their collective activities and interactions with the robots and mathematical tools.	- Integration of programming and robotics in mathematics education - Use of mathematical tools in problem-solving with robots - Collective learning processes and interaction among students - The role of the educator in facilitating learning through robotics - The evolving nature of mathematical tools from instruments to objects of focus in learning activities.	- Students utilised various mathematical tools in their robot-based activities, which evolved from being instrumental to becoming integral to the purpose of their tasks. - The teacher's role was crucial in facilitating students' engagement with mathematical concepts and in guiding the development of their collective learning. - Students showed a shift from trial-and-error strategies to systematic use of mathematical tools.	The educator acted as a facilitator rather than a direct instructor, guiding students' activities and encouraging them to engage with mathematical concepts. The teacher's suggestions helped to mathematised students' tasks, prompting them to use mathematics more formally while allowing for exploration and negotiation in their learning processes.	The findings suggest that integrating robotics into mathematics education can enhance students' understanding and application of mathematical concepts. However, the informal nature of robotics activities may challenge the formal teaching of mathematics. The study emphasises the need for educators to adapt their roles and teaching strategies to support this integration, potentially reshaping their professional identities.
9	The article explores how prospective elementary teachers (PTs) develop mathematics teaching that integrates cultural, linguistic, and cognitive resources from home and community settings with robotics. The research questions focus on how PTs connect mathematics learning with robotics and how they leverage community funds of knowledge and transdisciplinary connections in their instruction.	The study took place within initial teacher licensure programs at a public university in the southeastern United States, involving PTs from five sections of a master's-level elementary mathematics methods course. A total of 103 PTs participated, including master's candidates and undergraduate students seeking initial licensure across various areas, including K-5, PK-3, special education, and deaf education.	- Integration of robotics in mathematics teaching - Leveraging community funds of knowledge - Transdisciplinary connections in teaching - Equity and access in mathematics education - Professional identity of educators through technology use	- Robotics can facilitate engagement with mathematics concepts such as counting, distance, and sequencing. - PTs were able to connect their lessons with community knowledge, enhancing student engagement and making mathematics more accessible. - Transdisciplinary connections allowed for broader integration of concepts from other disciplines but were not consistently identified by PTs.	Educators acted as facilitators who guided PTs in designing and implementing robotics-based mathematics activities. They supported PTs in recognising the importance of community involvement and leveraging funds of knowledge, fostering a more equitable and inclusive approach to mathematics education. The integration of technology challenged PTs to rethink their instructional practices and professional identities.	The findings suggest that integrating robotics into mathematics instruction can enhance equity and accessibility, making learning more relevant to students' lives. It highlights the need for teacher educators to provide ongoing support as PTs navigate the complexities of integrating technology and community knowledge. Additionally, the study emphasises the potential for robotics to reshape educators' professional identities by broadening their understanding of teaching and learning contexts.

The following table (Figure 3) summarises the thematic overlap across the nine case studies presented in Figure 2 of the article. It draws only on the "Main Themes" identified for each case, grouping similar ideas—such as collaboration, teacher training needs, and mathematical reasoning—into common categories. By mapping these themes against all nine studies, the matrix highlights both widespread patterns (for example, active, student-centred learning appears in every case) and more specialised emphases such as equity or community connections, which emerge only in specific contexts. This overview provides a clear, at-a-glance view of how frequently each theme recurs and where distinctive contributions lie.

Figure 3. Main Theme Matrix

Main Theme	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Improvement of TPACK / teacher tech-pedagogy skills	✓		✓	✓					✓
Collaboration / social or collective learning	✓	✓	✓		✓	✓	✓	✓	✓
Active, hands-on or student-centred learning / engagement	✓	✓	✓		✓	✓	✓	✓	✓
Need for teacher training / professional development	✓		✓	✓	✓	✓		✓	✓
Mathematical understanding or reasoning gains	✓	✓	✓		✓	✓	✓	✓	✓
Programming / computational thinking development			✓			✓	✓	✓	
Equity / community or cultural connections									✓
Challenges & constraints (class size, resources, frustration, etc.)	✓		✓	✓					✓
Educator role shift / identity redefinition	✓	✓	✓	✓	✓	✓	✓	✓	✓

5. DISCUSSION

As evidenced in these case studies (Figure 2 & 3), the integration of AI-driven robotics into mathematics education stands at the intersection of innovation and tradition, presenting both opportunities and challenges for educators [9,10,53,54]. The integration of this technology into existing pedagogical practices has the potential to significantly reshape educators' professional identities (EPI) [11] within the profession. This discussion aims to delve deeper into the implications of this integration, particularly focusing on how it may facilitate a reterritorialization [40,41] of EPI and the emergence of a duality within these identities.

5.1. Potential to reterritorialize educators' professional identity

Reterritorialization [40,41] refers to the process by which social, cultural, or psychological structures, which have previously been destabilised or broken apart from their original contexts, are re-established or reconfigured within new or different territories [40]. In essence, reterritorialization describes how new arrangements, meanings, or identities emerge from the destabilisation of previous ones, emphasising the fluid, transformative nature of social and psychological life [41]. The concept of reterritorialization [40,41] suggests in the context of AI-driven robotics as an emerging pedagogical approach to mathematics education, it can lead to significant shifts in how educators perceive themselves within their professional roles [17-19]. This is because AI-driven robotics offers novel methodologies that challenge traditional teaching paradigms [22]. As educators engage with these technologies, they are often compelled to redefine their pedagogical approaches, which can result in a transformation of their professional identity [11].

This reterritorialization manifests in various ways. Educators may find themselves embracing new roles as facilitators of learning rather than mere transmitters of knowledge [55,56]. The use of robotics can encourage collaborative learning experiences, prompting educators to adopt a more constructivist approach that values student agency and engagement [10,12]. Consequently, this shift may lead educators to develop a more dynamic understanding of their role, seeing themselves as integral partners in the learning process rather than authoritative figures [13,53]. However, this redefinition is not without its complexities; as educators navigate these changes, they may encounter tensions between traditional practices and the demands of integrating advanced technologies [54,57].

5.2. A duality of professional identity

The findings from the case studies (Figure 2 & 3) a duality of professional identity emerges for educators as they incorporate AI-driven robotics into their teaching practices [9,10,12]. On one hand, educators may embrace the innovative methodologies that technology affords, fostering a sense of empowerment and engagement in their teaching. This facet of their identity is characterised by adaptability, enthusiasm for new pedagogical approaches, and a commitment to enhancing student learning experiences through technology. For instance, Casler-Failing, S. [10] highlights that pre-service teachers (PSTs) showed improvement in their Technological Pedagogical Content Knowledge (TPACK) through hands-on robotics instruction, fostering a sense of empowerment and engagement. This built on the previous work of Casler-Failing, S. [9] where they found the educator's role in facilitating a supportive learning environment emphasised the adaptation and enthusiasm for integrating technology, reinforcing the positive facet of educators' identities. This was similarly mirrored in Lopez-Caudana, et. al.'s [12] study which suggested that educators who embrace technology can enhance their teaching effectiveness and student learning experiences, reflecting a rewarding transformation in their professional identity.

On the other hand, there exists a contrasting aspect of professional identity rooted in the challenges and constraints posed by technology integration. Seckle, et. al.'s [57] study revealed that while teachers in Chile generally have positive conceptions regarding the integration of robotics, they face challenges such as large class sizes and limited resources. These constraints can lead to feelings of inadequacy and frustration, reflecting the tension between the desire to innovate and the reality of classroom management challenges. This struggle can was not only mirrored in the work of Rico-Bautista et. al. [53], but they also found it could lead to a sense of disconnection from their established professional identities, creating a tension between the desire to innovate and the fear of losing control over their teaching practices. The lack of significant improvement in science scores among students suggests that while robotics can enhance engagement in the work of Saez-Lopez, et. al., [54], furthermore, suggests that educators may feel challenged by the evolving demands of technology integration, contributing to feelings of inadequacy.

5.3. The significance of a reterritorialized identity

This duality reflects the ongoing negotiation that educators must undertake as they adapt to the evolving educational landscape shaped by AI [1-4]. Understanding this duality is crucial for developing supportive frameworks that empower educators, allowing them to navigate the complexities of integrating technology while maintaining a strong sense of EPI [17-19]. Regardless of to what extent this reterritorialized EPI will exist, its significance cannot be underestimated due to the cruciality of EPI in an educators' very practice [20,21].

In essence, an educator's professional identity (EPI) has the potential to directly influence, and affect the quality of, their teaching, development, and long-term career [58-60]. There is also a strong evidence base to assert that there is a strong link between an educator's EPI and notions of self-confidence in their professional abilities, [61,62] which will ultimately impact on not only the outcomes of their students but also the educational experiences yhat they have during their formal schooling years. The work conducted by Karousiou et. al. [19] also claimed that EPI can have a significant influence on an educator's interpretation, interaction with, and implementation of official educational policy and practices. The significance of AI-driven robotics acting as a form of reterritorialization [40,41] of EPI can therefore not be underestimated.

It must be noted however, that EPI, being a manifestation of 'self' or 'identity' [28], only comes into and maintains its existence through wider social interactions [29,30]. External others [30], or in the case of education, external stakeholder groups with their conflicting agendas will also mould an educator's EPI [22] which will also change over time as wider societal contexts change. Parents, students, policy makers and other key actors from the community in general, such as the labour market and the research community, all differ in the expectations they have towards schools [63]. Alongside this, the context in which teachers operate is also changing. The shift towards personalisation of learning [64], partly fuelled by AI-related integrations [65], and schools needing the meet the growing demands of an increasingly diverse pupil intake [19] will influence and shape an educator's EPI.

6. CONCLUSION

In conclusion, the 9 systematically selected case studies in this article present a compelling narrative: the integration of AI-driven robotics into mathematics education has the theoretical potential to reterritorialize educators' professional identity (EPI). More specifically, this reconstruction of EPI manifests itself in a dualistic nature, with educators striving to balance embracing new technologies that foster student engagement against the constraints of instructional effectiveness that create tension with traditional pedagogical roles. As we enter the AI age of education, this duality of EPI underscores the importance of understanding how technological advancements can reshape not only teaching practices but also educators' self-perceptions and professional growth.

Building on these insights, several concrete implications emerge for teacher training, professional development, and policy:

- Teacher training programmes should embed sustained, hands-on experiences with AI-driven robotics and related technologies, ensuring pre-service teachers develop both technological fluency and the reflective skills needed to navigate shifting professional identities.
- Ongoing professional development must move beyond one-off workshops to provide iterative, collaborative learning opportunities—such as professional learning communities and mentoring—that allow educators to experiment, share challenges, and integrate robotics meaningfully into mathematics curricula.
- Policy frameworks can support this work by funding technology-rich pilot programmes, establishing clear guidelines for equitable access to robotics resources, and recognising the evolving nature of educator roles in evaluation and accountability systems.

Such measures can help educators negotiate the duality described in this study, fostering a balanced professional identity that embraces innovation while addressing the real constraints of classroom practice. Ultimately, supporting educators in this way is crucial for enhancing the educational experience for both teachers and students in an increasingly AI-driven landscape.

Acknowledgements and Use of AI: The author would like to acknowledge and thank CCCU for funding the 2025 academics writing retreat which facilitated the completion of this manuscript. All written works within this artile are the original works of the author. While preparing this manuscript, the author employed AI-assisted tools, including ChatGPT, to aid in only the development of Figure 3. The output generated was carefully reviewed and revised by the author, who assumes full responsibility for the accuracy and integrity of the final content presented in this publication.

Funding Statement: This study was not funded by any external sources.

Author Contribution: The author contributed to the research and writing of this article and has read/agreed to the published version of the manuscript.

Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflict of Interest Statement: The author declares no conflicts of interest.

REFERENCES

1. Hu, L. (2022). Generative AI and future. https://pub.towardsai.net/generative-ai-and-future-c3b1695876f2
2. Baidoo-Anu, D., & Owusu Ansah, L. (2023). Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning. Journal of AI, 7(1), 52–62.
3. Mohamed, M., Hidayat, R., Suhaizi, N., Sabri, N., Mahmud, M., & Baharuddin, S. (2022). Artificial intelligence in mathematics education: A systematic literature review. International Electronic Journal of Mathematics Education, 17(3), em0694. https://doi.org/10.29333/iejme/12132
4. Clarke, S. (2025). Exploring the landscape of GenAI and education literature: A taxonomy of themes and sub-themes. British Educational Research Journal, 00, 1–32. https://doi.org/10.1002/berj.4186
5. Popenici, S., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. Research and Practice in Technology Enhanced Learning, 12(22), 1-13. https://doi.org/10.1186/s41039-017-0062-8
6. Stone, P., & 16 Study Panel members. (2016). Artificial intelligence and life in 2030, one-hundred-year study on artificial intelligence. Report of the 2015 Study Panel. Stanford University. https://ai100.stanford.edu/sites/g/files/sbiybj
7. Richter, A., Gacic, T., Koelmel, B., Waidelich, L., & Glaser, P. (2019). A review of fundamentals and influential factors of artificial intelligence. International Journal of Computer and Information Technology, 8(4), 142–156.
8. Grasse, O., Mohr, A., Lang, A., & Jahn, C. (2023). AI approaches in education based on individual learner characteristics: A review. In 2023 IEEE 12th International Conference on Engineering Education (ICEED). IEEE. (pp. 50 – 55) https://doi.org/10.1109/ICEED59801.2023.1026
9. Casler-Failing, S. (2018). Robotics and math: using action research to study growth problems. Canadian Journal of Action Research, 19 (2), 4-25.
10. Casler-Failing, S. (2021). Learning to teach mathematics with robots: Developing the 'T' in technological pedagogical content knowledge. Association for Learning Technology, 29, 1-20.
11. Davey, R. (2013). The Professional Identity of Teacher Educators: Career on the Cusp? London: Routledge.
12. Lopez-Caudana, E., Ramirez-Montoya, M., Martinez-Perez, S., & Rodriguez-Abitia, G. (2020). Using Robotics to Enhance Active Learning in Mathematics: A Multi-Scenario Study. Mathematics, 8 (2163), https://doi.org/10.3390/math8122163
13. Harper, F., Stumbo, Z., & Kim, N. (2021). When robots invade the neighbourhood: Learning to teach preK-5 mathematics leveraging both technology and community knowledge. Contemporary Issues in Technology and Teacher Education, 21(1), 19-52.
14. Atkinson, E. (2000). In defence of ideas, or why 'what works' is not enough. British Journal of Sociology of Education, 21(3), 307–330.
15. Blackmore, J. (2002). Is it only 'what works' that counts in new knowledge economies? Evidence based practice, educational research and teacher education in Australia. Social Policy and Society, 1(3), 257–266.
16. Hargreaves, D. (1996). Teaching as a research-based profession: possibilities and prospects. Teacher Training Agency Annual Lecture. In M. Hammersley (Ed.), Educational Research and Evidence-Based Practice (pp. 3-17). Milton Keynes: Open University Press.
17. Zhao, H., & Zhang, X. (2017). The influence of field teaching practice on pre-service teachers' professional identity: A mixed methods study. Frontiers in Psychology, 24(8), 1264. https://doi.org/10.3389/fpsyg.2017.01264
18. Cordingley, P., Crisp, B., Johns, P., Perry, T., Campbell, C., Bell, M., & Bradbury, M. (2019). Constructing Teachers' Professional Identities, Education International. Educational International & UNESCO.
19. Karousiou, C., Hajisoteriou, C., & Angelides, P. (2019). Teachers' professional identity in super-

diverse school settings: Teachers as agents of intercultural education. Teachers and Teaching, 25(2), 240-258.
20. Rodrigues, F., & M. Mogarro (2019). Student teachers' professional identity: A review of research contributions. Educational Research Review, 28, 100286. https://doi.org/10.1016/j.edurev.2019.100286
21. Mockler, N. (2020). Teacher professional learning under audit: reconfiguring practice in an age of standards. Professional Development in Education, 1-15.
22. Suarez, V. and McGrath, J. (2022). Teacher professional identify: how to develop and support it in times of change. OECD Education Working Paper No. 267. OECD.
23. Hanna, F., Oostdam, R., Severiens, S., & Zijlstra, B. (2019). Domains of teacher identity: A review of quantitative measurement instruments". Educational Research Review, 27, 15-27.
24. Bullough, R. (1997). Practicing theory and theorizing practice. In J. Loughran, & T. Russell (Eds.), Purpose, passion and pedagogy in teacher education (pp. 13-31). London: Falmer Press.
25. Connelly, F., & Clandinin, D. (1999). Shaping a professional identity: Stories of education practice. London, ON: Althouse Press
26. Beijaard, D., Meijer, P, & Verloop, N. (2004). Reconsidering research on teachers' professional identity. Teaching and Teacher Education, 20,107-128.
27. Erikson, E. (1968). Identity, youth and crisis. New York: W.W. Norton & Company.
28. McCormick, C., & Pressley, M. (1997). Educational psychology: Learning, instruction, assessment. New York: Longman.
29. Mead, G. (1934). Mind, self and society. Chicago: University of Chicago Press.
30. Gee, J. (2001). Identity as an analytic lens for research in education. In W. G. Secada (Ed.), Review of research in education, 25, 99-125. Washington, DC: American Educational Research Association.
31. Mockler, N. (2011). Beyond 'what works': understanding teacher identity as a practical and political tool. Teachers and Teaching: theory and practice, 17(5), 517-528.
32. Hall, D., & McGinity, R. (2015). Conceptualizing teacher professional identity in neoliberal times: Resistance, compliance and reform. Education Policy Analysis Archives, 23(88). http://dx.doi.org/10.14507/epaa.v23.2092.
33. Dewey, J. (1897) My Pedagogic Creed. School Journal, 54, 77-80. http://dewey.pragmatism.org/creed.htm
34. Nias, J. (1989). Primary teachers talking: A study of teaching as work. London: Routledge
35. Ogunleye, B., Zakariyyah, K., Ajao, O., Olayinka, O., & Sharma, H. (2024). A systematic review of generative AI for teaching and learning practice. Education Sciences, 14(6), 636. https://doi.org/10.3390/educsci14060636
36. Yusuf, A., Pervin, N., Roman-Gonzalez, M., & Md Noor, N. (2024). Generative AI in education and research: A systematic mapping review. BERA Review of Education, 12(2), 1–36. https://doi.org/10.1002/rev3.3489
37. Samala, A., Rawas, S., Wang, T., Reed, J., Kim, J., Howard, N., & Ertz, M. (2025). Unveiling the landscape of generative artificial intelligence in education: A comprehensive taxonomy of applications, challenges, and future prospects. Education and Information Technologies, 30, 3239–3278. https://doi.org/10.1007/s10639-024-12936-0
38. Willis, J. (2007). Foundations of qualitative research. Sage.
39. McChesney, K., & Aldridge, J. (2019). Weaving an interpretivist stance through mixed methods research. International Journal of Research and Method in Education, 42(3), 225–238.
40. Deleuze, G., & Guattari, F. (2010). O que é a filosofia? (3o ed). Editora 34
41. Deleuze, G., & Guattari, F. (2011). Mil Platôs: Capitalismo e esquizofrenia 2 (2o ed, Vol. 1). Editora 34.
42. Page, M., McKenzie, J., Bossuyt, P., Boutron, I., Hoffmann, T., Mulrow, C., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372(71), 1–9. https://doi.org/10.1136/bmj.n71
43. Greenhalgh, T. (2019). How to read a paper: The basics of evidence-based medicine. Wiley.
44. Flowerdew, J., & Habibie, P. (2021). Introducing English for research publication purposes. Routledge.
45. Jefferson, T., Alderson, P., Wager, E., & Davidoff, F. (2002). Effects of editorial peer review: A

systematic review. JAMA: The Journal of the American Medical Association, 287(21), 2784–2786.
46. McMillan, J., & Schumacher, S. (2013). Research in education: Evidence-based inquiry (7th ed.). Pearson.
47. Kvale, S. (2007). Doing interviews. SAGE.
48. Harkness, J., Braun, M., Edwards, B., Johnson, T., Lyberg, L., Mohler, P., Pennel B-E., & Smith, T. (2010). Survey methods in multinational, multiregional, and multicultural contexts. Wiley.
49. Lincoln, Y., Lynham, S., & Guba, E. (2011). Paradigm controversies, contradictions, and emerging confluences, revisited. In N. Denzin & Y. Lincoln (Eds.), The SAGE handbook of qualitative research (4th ed., pp. 191–215). SAGE.
50. Alvesson, M., & Sköldberg, K. (2018). Reflexive methodology: New vistas for qualitative research. SAGE.
51. Merriam, S., & Grenier, R. (2019). Qualitative research in practice: Examples for discussion and analysis (2nd ed.). Jossey-Bass.
52. Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. Qualitative Research in Sport, Exercise and Health, 11(4), 589–597.
53. Rico-Bautista, N., Rico-Bautista, D., & Medina-Cárdenas, Y. (2019). Collaborative work as a learning strategy to teach mathematics incorporating robotics using led godt education system and fischertechnik in seventh graders at the school Isidro Caballero Delgado in Floridablanca Santander Colombia. Journal of Physics: Conference Series, 1386 (012146), https://doi.org/10.1088/1742-6596/1386/1/012146
54. Saez-Lopez, J-M., Sevillano-Garcia, M-L., & Vazquez-Cano, E. (2019). The effect of programming on primary school students' mathematical and scientific understanding: educational use of mBot. Education Technology Research Development, 67, 1405–1425, https://doi.org/10.1007/s11423-019-09648-5
55. Francis, K., & Davis, B. (2018). Coding Robots as a Source of Instantiations for Arithmetic. Digital Experiences in Mathematics Education, 4, 71–86. https://doi.org/10.1007/s40751-018-0042-7
56. Forsström, S., & Afdal, G. (2020). Learning Mathematics Through Activities with Robots. Digital Experiences in Mathematics Education, 6, 30–50. https://doi.org/10.1007/s40751-019-00057-0
57. Seckel, M., Breda, A., Font, V., & Vásquez, C. (2021). Primary School Teachers' Conceptions about the Use of Robotics in Mathematics. Mathematics, 9 (3186), https://doi.org/10.3390/math9243186
58. Agee, J. (2004). Negotiating a teaching identity: An African American teacher's struggle to teach in test driven contexts. Teachers College Record, 106(4), 747-774.
59. Korthagen, F. (2004). In search of the essence of a good teacher: towards a more holistic approach in teacher education. Teaching and Teacher Education, 20(1), 77-97.
60. Rots, I., Aelterman, A., Devos, G., & Vlerick, P. (2010). Teacher education and the choice to enter the teaching profession: A prospective study. Teaching and Teacher Education, 26(8), 619-1629.
61. Day, C., Elliot, B., & Kington, A. (2005). Reform, standards and teacher identity: Challenges of sustaining commitment. Teaching and Teacher Education, 21(5), 563-577.
62. Galman, S. (2009). Doth the lady protest too much? Pre-service teachers and the experience of dissonance as a catalyst for development. Teaching and Teacher Education, 25(3), 468-481.
63. OECD (2020). TALIS 2018 Results (Volume II): Teachers and School Leaders as Valued Professionals. TALIS, OECD Publishing, Paris, https://dx.doi.org/10.1787/19cf08df-en.
64. Schleicher, A. (2018). Valuing our Teachers and Raising their Status: How Communities Can Help. International Summit on the Teaching Profession, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264292697-en
65. Lanas, M. & Kelchtermans, G. (2015). "This has more to do with who I am than with my skills" – Student teacher subjectification in Finnish teacher education. Teaching and Teacher Education, 47, 22-29.