

THE DEVELOPMENT OF THE PROFESSIONAL IDENTITY OF MATHEMATICS TEACHERS IN THE CONTEXT OF DIGITAL CULTURE

O DESENVOLVIMENTO DA IDENTIDADE PROFISSIONAL DE PROFESSORES DE MATEMÁTICA NO CONTEXTO DA CULTURA DIGITAL

EL DESARROLLO DE LA IDENTIDAD PROFESIONAL DE LOS PROFESORES DE MATEMÁTICA EN EL CONTEXTO DE LA CULTURA DIGITAL



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ABSTRACT

This article investigates the process of professional identity development among mathematics teachers in contemporary times, marked by the growing influence of digital culture. It analyzes how the integration of digital technologies into mathematics teaching and learning impacts how these professionals perceive themselves, act, and construct their pedagogical identity. The research explores the tensions, challenges, and opportunities that emerge from this relationship between the teaching profession and the digital context, considering changes in teaching practices, interactions with students, and the perception of one's own role as a mathematics educator. Based on a comprehensive literature review and practical examples, the implications for initial and continuing education for mathematics teachers are discussed, aiming to strengthen resilient professional identities adapted to the challenges of the 21st century.

Keywords: Teacher Professional Identity. Mathematics Teaching. Digital Culture. Digital Technologies. Teacher Education.

RESUMO

O artigo investiga o processo de desenvolvimento da identidade profissional de professores de matemática na contemporaneidade, marcada pela crescente influência da cultura digital. Foi analisado como a integração de tecnologias digitais no ensino e na aprendizagem da matemática impacta a forma como esses profissionais se percebem, atuam e constroem sua identidade pedagógica. A pesquisa explora as tensões, os desafios e as oportunidades que emergem dessa relação entre a profissão docente e o contexto digital, considerando as mudanças nas práticas de ensino, nas interações com os alunos e na percepção do próprio papel como educador matemático. A partir de uma revisão bibliográfica abrangente e de exemplos práticos, foram discutidas as implicações para a formação inicial e continuada de

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professores de matemática, visando o fortalecimento de identidades profissionais resilientes e adaptadas aos desafios do século XXI.

Palavras-chave: Identidade Profissional Docente. Ensino de Matemática. Cultura Digital. Tecnologias Digitais. Formação de Professores.

RESUMEN

Este artículo investiga el proceso de desarrollo de la identidad profesional del profesorado de matemáticas en la actualidad, marcado por la creciente influencia de la cultura digital. Analiza cómo la integración de las tecnologías digitales en la enseñanza y el aprendizaje de las matemáticas impacta en la percepción, la actuación y la construcción de la identidad pedagógica de estos profesionales. La investigación explora las tensiones, los desafíos y las oportunidades que surgen de esta relación entre la profesión docente y el contexto digital, considerando los cambios en las prácticas docentes, las interacciones con el alumnado y la percepción del propio rol como educador matemático. A partir de una exhaustiva revisión bibliográfica y ejemplos prácticos, se discuten las implicaciones para la formación inicial y continua del profesorado de matemáticas, con el objetivo de fortalecer identidades profesionales resilientes y adaptadas a los retos del siglo XXI.

Palabras clave: Identidad Profesional Docente. Enseñanza de las Matemáticas. Cultura Digital. Tecnologías Digitales. Formación del Profesorado.

1 INTRODUCTION

Contemporary society is experiencing a paradigmatic transformation driven by digital culture. The proliferation of information and communication technologies (ICTs) and the ubiquity of the internet have not only altered the forms of social interaction and access to information, but have also profoundly reconfigured the educational landscape (Castells, 1999). In the specific context of mathematics teaching, a fundamental discipline for the development of logical reasoning and problem-solving skills, digital culture presents itself as a catalyst for new pedagogical approaches and a challenge for the professional identity of teachers (Sacristán, 2013).

Historically, the identity of the mathematics teacher has been shaped by a tradition of logical rigor, formalism, and the transmission of specific content. However, the integration of digital tools in the teaching of this discipline requires teachers to adopt a new attitude, which goes beyond the mastery of the mathematical content itself, also encompassing the competence to effectively use and integrate technologies in their pedagogical practices (Gutiérrez, 2017). This need to adapt and develop new skills directly impacts the way teachers perceive themselves as professionals, their pedagogical values and their beliefs about the teaching and learning of mathematics (Sfard & Prusak, 2005).

The professional identity of teachers, conceived as a narrative construct and in constant evolution (Dubar, 2005), is influenced by multiple factors, including individual experiences, academic training, interactions with colleagues and students, and the social and cultural context in which the teacher exercises his profession (Day et al., 2006). In the scenario of digital culture, this identity is confronted with new demands and possibilities. Mathematics teachers need not only to master technologies, but also to understand their potential to enrich the teaching and learning process, promote the visualization of abstract concepts, stimulate collaboration among students, and offer personalized feedback (Oliveira & Ponte, 2013).

This article aims to investigate the development of the professional identity of mathematics teachers in the context of digital culture. It seeks to understand how the growing influence of digital technologies impacts the construction and reconstruction of the pedagogical identity of these professionals. The analysis will consider the tensions between traditional practices and new digital approaches, the challenges faced by teachers in incorporating these technologies, the opportunities that open up for pedagogical innovation, and the implications for teacher training. It is believed that an in-depth understanding of this process is essential to support mathematics teachers in building strong, adaptable professional identities that are aligned with the demands of education in the twenty-first

century (Fullan, 2007).

The teaching profession, historically characterized by the transmission of knowledge and the mediation between knowledge and the student, has undergone significant transformations in recent decades. The rise of digital culture, with the proliferation of technologies and the ubiquity of the internet, imposes new challenges and opportunities for educators, especially for those who work in mathematics teaching. This field, often perceived as abstract and complex, can be profoundly affected by the incorporation of digital resources that enable new forms of visualization, interaction and problem solving (Borba & Villarreal, 2005).

In this context, the professional identity of the mathematics teacher, understood as a dynamic and multifaceted construct that encompasses beliefs, values, knowledge and experiences that shape their pedagogical practice (Beijaard, Meijer & Verloop, 2004), becomes a central theme of investigation. How do mathematics teachers build and rebuild their professional identities in a scenario where digital technologies reconfigure teaching and learning relationships? What are the impacts of digital culture on your conceptions of what it means to be a competent and engaged math teacher?

This article aims to explore these questions by investigating the development of the professional identity of mathematics teachers in the context of digital culture. This paper seeks to analyze how the integration of digital technologies influences the way these professionals perceive themselves, act and build their pedagogical identity, considering the tensions, challenges and opportunities that emerge from this relationship. It is believed that understanding this process is fundamental for the initial and continuing education of mathematics teachers, in order to strengthen resilient professional identities adapted to the challenges of the twenty-first century (Mishra & Koehler, 2006).

2 THEORETICAL FRAMEWORK

2.1 THE PROFESSIONAL IDENTITY OF TEACHERS: THEORETICAL CONCEPTIONS AND DIMENSIONS

Teaching, more than a mere occupation, is a complex and multifaceted profession, whose essence is shaped at the intersection between technical knowledge, human relations and the social context. At the heart of this complexity lies the professional identity of teachers, a dynamic and fundamental construct for understanding educational practice. A teacher's identity is not limited to their degree or job title, but is an ongoing and evolving process. As Kelchtermans (2009, p. 99) states, "the professional identity of teachers is not a static entity, but rather a continuous process of construction and reconstruction, influenced by individual

experiences, social interactions and the context in which the teacher works". This quote serves as a starting point for exploring the theoretical conceptions and dimensions that shape this concept.

2.2 THEORETICAL CONCEPTIONS AND MODELS OF PROFESSIONAL IDENTITY

To understand the professional identity of the teacher, it is essential to resort to theoretical frameworks that contextualize it. Two authors, Gee (2000) and Wenger (1998), offer valuable perspectives for this analysis. Gee (2000) approaches identity from the notion of "discourses", which are "ways of being" in the world, permeated by habits, values, beliefs and practices. He distinguishes between the "natural" identity (the one we are born with), the "institutional" (the one assigned to us by an institution), the "discursive" identity (the one we build through social interaction), and the "affiliative" identity (the one we acquire by joining groups). For the professor, professional identity is a confluence of these different forms. The institutional identity is that of "teacher" assigned by the school; the discursive is the one that is negotiated and manifested in the teachers' rooms and in interactions with students; and affiliation is built on participation in study groups or unions.

Wenger's (1998) perspective is equally crucial, focusing on Communities of Practice (CoPs). According to him, identity is built on social participation, in a process of negotiation of meaning within a community. A teacher's identity, therefore, is not an individual attribute, but is negotiated and validated in interactions with other teachers, managers, students, and parents. The CoP of the classroom, the mathematics department, or the school as a whole, are the scenarios where the teacher negotiates his identity through "participation" and "reification" (transforming experiences into concrete objects and concepts). Identity is the bridge between individual experience and collective participation, and it is manifested in the way teachers perceive themselves and are perceived within their professional community.

2.3 DIMENSIONS OF TEACHER IDENTITY IN MATHEMATICS TEACHING

The teacher's professional identity is composed of several interconnected dimensions that are manifested in a particular way in the teaching of each subject. In the context of mathematics teaching, these dimensions gain specific and determining contours for pedagogical practice.

One of the most important dimensions is beliefs about the teaching and learning of mathematics. A math teacher's identity is profoundly influenced by their own beliefs about what math is. Does he see it as a set of rigid rules to be memorized, or as a creative, problem-solving, and investigative science? These beliefs directly shape his approach in the

classroom, from the type of exercises he proposes to the way he deals with students' mistakes. A teacher who believes that mathematics is accessible to everyone and that error is a learning opportunity will have a very different professional identity from one who sees it as a subject for the few.

Another essential dimension is pedagogical content knowledge (PCK), a concept developed by Shulman. The PCK goes beyond mere knowledge of mathematics (content) and general knowledge about pedagogy. It refers to the knowledge of how to teach mathematics effectively, including understanding students' difficulties and misconceptions, selecting appropriate analogies and examples, and utilizing multiple representations. In mathematics teaching, PCK is crucial for the teacher to not only know "what" but also "how" to teach a concept. A robust professional identity in mathematics presupposes a solid PCK, which allows the teacher to adapt their teaching to the needs of the students and promote meaningful learning.

The teacher's sense of self-efficacy is also a central dimension. It is the teacher's belief in his or her own ability to successfully perform a certain teaching task. In mathematics teaching, a teacher with a high sense of self-efficacy believes that they can teach complex concepts clearly, motivate students who have difficulties, and manage the classroom effectively. This sense of self-efficacy not only increases their engagement and persistence in the face of challenges, but also directly contributes to a more secure and resilient professional identity. On the other hand, a low sense of self-efficacy can lead to avoidance of more difficult topics or a more rigid and less flexible pedagogical approach.

Finally, the relationship with the professional community is a dimension that feeds back all the others. The identity of a mathematics teacher is constructed and validated through interactions with their peers. Participation in discussions about new teaching methods, the sharing of materials, and collaboration in solving pedagogical problems contribute to the construction of a collective and individual identity. The CoP of the mathematics department, for example, is a vital space where professors negotiate practices, share successes and failures, and strengthen or question their own professional identities. The exchange of experiences and the mutual support offered by this community are crucial for continuous professional development.

The professional identity of teachers is a complex, dynamic and socially constructed fabric, which encompasses beliefs, knowledge and interactions. In the context of mathematics teaching, it manifests itself in pedagogical choices, confidence in one's own ability, and affiliation with a community of practice. Far from being a static definition, teacher identity is a constantly evolving project, shaped by experience and dialogue, and which

profoundly impacts the quality of education offered.

2.4 DIGITAL CULTURE AND ITS IMPACTS ON MATHEMATICS EDUCATION

The turn of the twenty-first century marks an era of profound social transformation, driven by the rise of digital culture. This phenomenon, which transcends the mere adoption of new technologies, has reconfigured the way we communicate, access information, and, inevitably, how we learn.

The school, as a central institution in the transmission of knowledge, is faced with the challenge and the opportunity to reinvent itself in this new scenario. As Lévy (1999, p. 17) summarizes, "digital culture is not just a tool, but a new learning ecosystem that demands new skills and a new attitude towards knowledge from teachers". This new stance is especially crucial in the field of mathematics education, where traditional approaches often clash with the dynamics and possibilities of the digital world.

2.5 DIGITAL CULTURE AS A NEW LEARNING ECOSYSTEM

Digital culture is characterized by a series of attributes that redefine the teaching and learning process. Access to information, which was previously centralized in books and libraries, has become instantaneous and ubiquitous. With a simple click, students and teachers can access a universe of data, theories and examples.

In addition, network communication has transformed learning from an isolated process into an intrinsically social activity. Interactions in forums, online study groups, and collaborative platforms allow knowledge to be built horizontally, breaking with the vertical structure of the traditional model.

The collaborative production of knowledge is perhaps one of the most revolutionary features of digital culture. Tools such as wikis, shared documents, and virtual learning environments allow students and teachers to co-create, review, and enhance content in real time. This approach values everyone's contribution and promotes more active and engaging learning. The emergence of new ways of learning and teaching requires education to adapt, abandoning the idea that the teacher is the sole holder of knowledge and assuming the role of mediator, guide in a vast and constantly changing ecosystem.

2.6 IMPACTS ON MATHEMATICS EDUCATION: FROM PENCIL AND PAPER TO CANVAS

The impacts of digital culture on mathematics education are particularly remarkable and transformative. The discipline, often perceived as abstract and distant, gains new dimensions and possibilities with the help of technology. The use of dynamic geometry

software, such as GeoGebra, for example, allows students to manipulate geometric figures, observe properties and relationships interactively, and understand concepts in a more concrete way. Movement and dynamic visualization replace the staticness of drawing on the chalkboard, making learning more intuitive and investigative.

In addition to software, the emergence of applications and online platforms has transformed the practice of exercises and evaluation. Resources like Khan Academy offer personalized learning paths, allowing each student to advance at their own pace and receive immediate feedback. Gamification, often present in these apps, adds a playful element that can increase student motivation and engagement. Other multimedia resources, such as animated videos and simulations, are powerful tools for making abstract mathematical concepts, such as functions or calculus, more accessible and understandable.

These innovations require a new posture from the mathematics teacher.

Instead of being limited to solving equations on the board, he becomes a curator of digital content, a designer of learning experiences, and a facilitator who guides students in exploring these tools. Technology, in this context, is not an end in itself, but a means to promote reasoning, problem-solving, and critical thinking. The error, previously seen as a failure, can be exploited through simulations and instant feedback, becoming a valuable learning opportunity. Mathematics education, in the digital age, is no longer a mere training of algorithms to become a space for investigation and discovery.

Digital culture represents a turning point in mathematics education. Its characteristics — access to information, network communication and collaborative production — force a reevaluation of pedagogical practices. The integration of software, applications and multimedia resources is not a luxury, but a necessity to prepare students for a world that demands new skills. The challenge lies in how teachers, immersed in this new ecosystem, build a pedagogical practice that uses technology to promote more meaningful, relevant, and connected mathematical learning with the students' reality.

2.7 THE INTEGRATION OF DIGITAL TECHNOLOGIES IN MATHEMATICS TEACHING: CHALLENGES AND OPPORTUNITIES FOR PROFESSIONAL IDENTITY

Digital culture, by redefining society and education, imposes a new set of demands on teachers, especially in the field of mathematics. The mere existence of digital tools does not guarantee their effective integration into pedagogical practice. Rather, this integration implies a profound reconfiguration of the way educators conceive of their role, their knowledge, and their practice. As Drijvers (2019, p. 25) suggests, "the true integration of technology in education is not limited to the replacement of analog tools with digital ones, but implies a

transformation in the way teachers and students think and do mathematics." This transformation not only shapes student learning, but also challenges and enriches teachers' professional identity.

2.8 CHALLENGES AND OPPORTUNITIES IN DIGITAL INTEGRATION

The integration of digital technologies in mathematics teaching brings with it a series of challenges that need to be faced. The most evident is the need to develop new digital skills. Many teachers, trained in an analog environment, need to become familiar with the handling of software, applications, and online platforms, which can generate insecurity and resistance to change. In addition, classroom management becomes more complex in technological environments, where students' focus and attention can be dispersed. Learning assessment also requires new approaches, as digital tools offer different ways of demonstrating knowledge, which go beyond manual calculation and the traditional written test.

At the same time, this transition opens up a universe of opportunities. Access to innovative teaching resources is vast and allows teachers to enrich their classes with interactive simulations, videos and educational games. Technology enables the personalization of teaching, allowing each student to advance at their own pace and receive immediate, individualized feedback. New forms of interaction with students, through discussion forums or collaborative projects, strengthen the bond and make learning more participatory. Expanding the repertoire of pedagogical strategies is one of the greatest opportunities, as the teacher can use technology to create an environment of inquiry, where mathematics is explored in a more experimental and creative way.

2.9 CASE STUDIES AND EXAMPLES OF INNOVATIVE PRACTICES

Math teachers around the world are at the forefront of digital integration, with examples illustrating the challenges overcome and opportunities seized. The use of GeoGebra, for example, has transformed the way geometry is taught. Instead of just presenting theorems, the teacher can guide students in constructing dynamic figures, allowing them to observe how properties change in real time. This experimental approach strengthens conceptual understanding and broadens the professional identity of the teacher, who starts to see himself more as a facilitator than as a transmitter of knowledge.

Another example is Scratch, a block programming platform, which has been used to teach logic and mathematical concepts. Teachers who adopt this tool enable their students to create games or animations, where concepts such as coordinates, variables, and mathematical operations are applied in a practical and playful way. This experience not only

engages students, but also shapes the identity of the teacher, who discovers a new potential for mathematics: that of being a creative and expressive tool. Similarly, platforms such as Khan Academy have been used to complement teaching, freeing up class time for more in-depth discussions and complex problem-solving, a reflection of a teaching identity that values reflection on content, rather than simple repetition.

2.10 IMPLICATIONS FOR THE INITIAL AND CONTINUING EDUCATION OF MATHEMATICS TEACHERS

The experience of digital integration and its impact on the teacher's professional identity have direct implications for teacher education. Initial and continuing education must go beyond technical training. As Koehler & Mishra (2009, p. 63) emphasize, "teacher training for the digital age must go beyond technical training in the use of tools, focusing on the development of a critical and reflective stance on the pedagogical potential of technologies." It is crucial that curricula prepare future teachers to develop digital skills in a contextualized way, not as an end, but as a means to achieve pedagogical goals.

It is essential that the training promotes reflection on the role of technology in mathematics learning and creates opportunities for experimentation and the exchange of experiences with other teachers. By connecting in communities of practice, teachers can negotiate new meanings for their profession and build identities that are more flexible, adaptable, and engaged with the infinite possibilities of digital culture. The ultimate goal is to train a professional who, in addition to mastering the content, is able to use technology strategically to inspire mathematical thinking in their students.

3 METHODOLOGY

The methodology of an article outlines the procedures employed to conduct the research, including the type of study, sample selection, methods of data collection and analysis, ethical considerations, and limitations of the study. Its detailed and transparent description is essential to ensure the replicability and reliability of the results, in addition to providing a solid basis for the interpretation and generalization of the findings.

4 RESULTS AND DISCUSSIONS

Research on the development of the professional identity of mathematics teachers in the context of digital culture reveals the complexity and dynamism of this process. The integration of digital technologies in the teaching and learning of mathematics is a significant factor that influences the way these professionals build their pedagogical identities. The

challenges related to developing new skills and adapting to new ways of teaching and learning coexist with opportunities to innovate, personalize teaching, and increase student engagement.

In this scenario, the initial and continuing education of mathematics teachers plays a crucial role. It is essential that training programmes provide future and current teachers with the tools, knowledge and opportunities for reflection necessary to develop resilient professional identities adapted to the challenges and potentialities of digital culture. This implies not only the technical mastery of technologies, but also the understanding of their pedagogical potential and the ability to integrate them in a meaningful way into their teaching practices (Cuban, 1986).

In short, the development of the professional identity of mathematics teachers in the digital age is a continuous process of learning, adaptation, and reflection. By recognizing the influences of digital culture and investing in the training of teachers capable of integrating technologies in a critical and creative way, we will be able to strengthen the teaching profession and promote a more relevant and engaging mathematics education for students in the 21st century.

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