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Ten years of the curriculum and digital technologies in mathematics education group: research paths in/for teacher training

Diez años del grupo currículo y tecnologías digitales en educación matemática: caminos de investigación en/para la formación docente

Dix ans du groupe curriculum et technologies numériques dans l'enseignement des mathématiques : parcours de recherche en/pour la formation des enseignants

Dez anos do grupo currículo e tecnologias digitais em educação matemática: percursos de pesquisa na/para formação docente

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Abstract

This article provides an overview of research and actions carried out over a decade by the research group "Curriculum and Digital Technologies in Mathematics Education" (CTDEM), emphasizing methodologies and theoretical lenses adopted, integrating teachers in initial and continuing training at different levels and contexts. Through qualitative meta-analysis, it became possible to demonstrate that research and actions brought contributions, such as the structuring of educational products, extension courses, *softwares*, teaching sequences, catalogs and tutorials, and the publication of articles and organization of extension events, promoting integration with Basic Education. The research carried out so far points to teaching with digital technologies in initial and continuing education, indicating demands for future research from CTDEM with a focus on Early Years, plugged and unplugged activities regarding the relationship between Mathematics and Computational Thinking, and research on the impacts and possibilities of Generative Artificial Intelligence, which can give rise to innovative didactic situations and professional practices for teaching mathematics at different levels and modalities.

Keywords: Research Group, Teacher training, Digital technologies, Curriculum, Mathematics education.

Resumen

Este artículo ofrece un panorama de las investigaciones y acciones realizadas a lo largo de una década por el grupo de investigación "Curriculum y Tecnologías Digitales en la Educación

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Matemática" (CTDEM), enfatizando las metodologías y lentes teóricos adoptados, integrando a los docentes en la formación inicial y continua en diferentes niveles y contextos. A través de metaanálisis cualitativo, fue posible demostrar que investigaciones y acciones trajeron aportes, como la estructuración de productos educativos, cursos de extensión, *softwares*, secuencias didácticas, catálogos y tutoriales, y la publicación de artículos y organización de eventos de extensión, promoviendo integración con la Educación Básica. Las investigaciones realizadas hasta el momento apuntan a la enseñanza con tecnologías digitales en la educación inicial y continua, indicando demandas de futuras investigaciones desde el CTDEM con enfoque en la Primera Infancia, actividades conectadas y desconectadas sobre la relación entre Matemática y Pensamiento Computacional, e investigaciones sobre los impactos y posibilidades de la Inteligencia Artificial Generativa, que pueden dar lugar a situaciones didácticas y prácticas profesionales innovadoras para la enseñanza de las matemáticas en diferentes niveles y modalidades.

Palabras clave: Grupo de investigación, Formación de docentes, Tecnologías digitales, Plan de estudios, Educación Matemática.

Résumé

Cet article donne un aperçu des recherches et des actions menées depuis une décennie par le groupe de recherche « Curriculum et technologies numériques dans l'enseignement des mathématiques » (CTDEM), en mettant l'accent sur les méthodologies et les optiques théoriques adoptées, intégrant les enseignants en formation initiale et continue à différents niveaux et contextes. Grâce à une méta-analyse qualitative, il est devenu possible de démontrer que la recherche et les actions apportaient des contributions, telles que la structuration de produits éducatifs, de cours de vulgarisation, de logiciels, de séquences pédagogiques, de catalogues et de tutoriels, ainsi que la publication d'articles et l'organisation d'événements de vulgarisation, favorisant intégration avec l'éducation de base. Les recherches menées jusqu'à présent pointent vers l'enseignement avec les technologies numériques dans la formation initiale et continue, indiquant des demandes de recherches futures de la part du CTDEM avec un accent sur la petite enfance, les activités branchées et débranchées concernant la relation entre les mathématiques et la pensée computationnelle, et la recherche sur les impacts et les possibilités de l'Intelligence Artificielle Générative, qui peuvent donner lieu à des situations didactiques et des pratiques professionnelles innovantes pour l'enseignement des mathématiques à différents niveaux et modalités.

Mots-clés : Groupe de recherche, Formation des enseignants, Technologies numériques, Programme d'études, Enseignement des mathématiques.

Resumo

O presente artigo traz um panorama de pesquisas e ações realizadas em uma década pelo grupo de pesquisa Currículo e Tecnologias Digitais em Educação Matemática (CTDEM), enfatizando metodologias e lentes teóricas adotadas, integrando professores em formação inicial e continuada em diferentes níveis e contextos. Por meio da metanálise qualitativa, tornou-se possível evidenciar que as pesquisas e ações trouxeram contribuições – como a estruturação de produtos educacionais, cursos de extensão, *softwares*, sequências didáticas, catálogos, tutoriais, a publicação de artigos e a organização de eventos extensionistas – promovendo integração com a Educação Básica. As pesquisas realizadas até o momento apontam um olhar para o ensino com tecnologias digitais na formação inicial e continuada, indicando demandas de pesquisas futuras do CTDEM com foco nos Anos Iniciais, atividades plugadas e desplugadas a respeito da relação Matemática e Pensamento Computacional, e pesquisas sobre os impactos e possibilidades das Inteligências Artificiais Generativas, que podem suscitar situações didáticas e práticas profissionais inovadoras para o ensino de matemática em diferentes níveis e modalidades.

Palavras-chave: Grupo de pesquisa, Formação de professores, Tecnologias digitais, Currículo, Educação matemática.

Ten years of the Curriculum and Digital Technologies in Mathematics Education (CTDEM) group: research paths in/for teacher training

The research group Curriculum and Technologies in Mathematics Education (CTDEM) is configured as a space of reflection and discussion, together with undergraduate and graduate students, considering as a problem the distance between school subjects and the most current theories of the curriculum as problematic, mainly because discussions in the field of curriculum are becoming more theoretical; above all, because it is a field of study still in the consolidation phase in Brazil. On the other hand, discussions about the organization and development of the curriculum in Mathematics within the Group are constant and strongly marked by the concern to articulate the different elements that specify the normative dimension of the curriculum such as the objective, the mathematical content, the teaching resources, the assessment, the methodology, among others.

Regarding technologies, over the course of a decade, the group's research have been analyzing how methodological recommendations are configured in prescribed curricula and how they are implemented in practice, proposing teaching situations with existing software and structuring digital environments and tools in order to enhance the teaching transposition of curricular content.

In this sense, this article aims to present and analyze contributions from these studies, as well as highlight the scientific productions developed and published, their theoretical-methodological emphasis, the collection instruments, the subjects and the educational products/processes generated, which allow new studies to be envisioned through the meta-analysis of research already developed within the scope of CTDEM.

The group is certified by CNPQ and was created in 2015, configuring itself as a space for reflection, discussion and learning with students of the mathematics course and master's students of the Graduate Program in Teaching of the Instituto do Noroeste Fluminense of the Universidade Federal Fluminense (PPGEn/INFES/UFF). In 2021, the group continued its activities at the Federal Rural University of Rio de Janeiro (UFRRJ), having its headquarters at the Multidisciplinary Institute (IM), integrating students of the Bachelor's degrees in Pedagogy and Mathematics and master's students of the Graduate Program in Education in Science and Mathematics (PPGEduCIMAT).

Over these 10 years, the CTDEM group has organized seminars and conferences of national and local scope, disseminating the research developed through the publication of annals, articles and books and implementing extension actions and continuing education for teachers.

Methodology

As a methodology for the survey carried out in the context of the CTDEM group, qualitative research of the meta-analysis type was adopted, which preserves the general aspects of the research in the new analysis, without modifying the essence of the research analyzed (Alencar & Almouloud, 2017 apud Kiefer & Mariani, 2021, p. 410).

In that regard,

> [...] qualitative meta-analysis emerges as a type of systematic review of qualitative studies and can be an in-depth study involving a small number of investigative works. The results of these studies can be integrative, cross-referenced or contrasted with the aim of producing broader or more general results. [...] (Fiorentini, 2014, p. 78).

According to Fiorentini and Lorenzato (2007, p. 103 apud Santos & Vasconcelos, 2019, p. 364), this modality "is a systematic review of other research, aiming to carry out a critical evaluation of them and/or produce new results or syntheses from the comparison of these studies, transcribing those previously obtained". The research consisted of gathering the works developed by the group – over a decade – by reading the title, abstract; in some cases, reading the texts in full: course completion papers, dissertations, scientific initiation research reports and articles. After selecting the works, debates and reflections were developed based on a critical look at the productions of the CTDEM Group, focusing on the curriculum, technologies, methodologies and results (limitations and potentialities), allowing for a vision of a given moment, considering these varied dimensions and contexts.

Considering the importance of review studies, in addition to the purpose of understanding relative aspects of research, meta-analysis can assist in the process of reflections on the promotions, events and continuing education courses promoted during these ten years of the CTDEM Group's constitution, with emphasis on institutional, procedural and thematic aspects, the resulting productions, as well as categorizing ongoing investigations and envisioning future research to be developed by the group.

Presentation and analysis of data

This section aims to present elements and results of research developed within the scope of the CTDEM group, such as the theoretical and methodological principles adopted, the different objectives, the natures, institutions and educational contexts translated into Course Conclusion Papers (TCC), Master's dissertations, Scientific Initiation, and other developments such as funding notices, holding of events, promotion of continuing education courses with an extensionist character and publication of articles.

Below, in Table 1, are listed the TCCs that were developed by students of the Bachelor's Degree courses in Mathematics and Pedagogy in different contexts:

Table 1

Course Conclusion Papers developed within the scope of CTDEM

Author	Title	Course	IES
Souza (2016)	Numbers: Their Approach in Textbooks Using the History of Mathematics as a Methodological Tool	Bachelor's Degree in Mathematics	UFF
Souza (2017)	Georun Computer Game via Scratch for Analysis of Geometric Development: A Case Study through Didactic Engineering		
Vieira (2017)	Psychology of Mathematical Education: Curriculum Development and Cognition in Geometry		
Silva (2017)	Van Hiele's Geometric Model: State of the Art of National Meetings on Mathematics Education in the 21st Century		
Lima (2023)	Commercial Games as a Pedagogical Strategy for Students in the Final Years of Elementary School (E.F.): a Systematic Literature Review	Bachelor's Degree in Pedagogy	UFRRJ
Fernandes (2025)	RPG in the teaching of Mathematics and Sciences in the Early Years (In press)		
Cortes (2025)	Teaching conceptions of future Mathematics teachers of the Institutional Program for Teaching Initiation (PIBID) of IM/UFRRJ (In press)	Bachelor's Degree in Mathematics	

Souza (2016) adopted the qualitative research methodology (description and analysis) to analyze 6th grade Mathematics textbooks of elementary school, following the criteria of the National Book and Teaching Material Program (PNLD), the National Curricular Parameters (PCN) and researchers, to verify the approach of the History of Mathematics as a methodology. The aforementioned author concludes that the approach is present in the content, but – most of the time – in a summarized form and only as a story about the emergence of a certain concept: increasingly present in the books and can motivate students in the construction of knowledge.

The study by Souza (2017) addressed concepts of Plane Geometry through the Van Hiele Model, building a Didactic Engineering and addressing the PCN and the BNCC. It also structured software in Scratch 1.4, where activities from the model were adapted. Undergraduate students in Mathematics from INFES/UFF participated; after preliminary analyses, a teaching section was developed in GeoGebra, contributing to the construction of geometric knowledge. The comparison of the results of the analysis, a priori and a posteriori, showed the evolution of knowledge after the intervention.

Vieira's Paper (2017) conducted a study on the understanding of how mental schemes work, their functioning and their relationship with the understanding of geometric thinking, highlighting aspects of cognitive development with the help of cognitive theories such as the Van Hiele model. This deals with Geometric Thinking from levels that vary according to the development of the child's maturity. According to the analysis of official documents – PCN and

BNCC – the need to adopt new educational practices was found; consequently, investments in teacher training to promote meaningful learning for students.

Still from the perspective of visualization in Geometry, Silva (2017) mapped the works on the Van Hiele model, published at the National Meetings on Mathematics Education (ENEM) held in the 21st century. These meetings are one of the most important events in the area and due to the widespread adoption of the model since the 1980's; in addition to being, to this day, the most accepted cognitive model in Geometry. The approaches, contexts, similarities and specificities were analyzed in order to verify the state of the art, highlighting gaps in the theory; among these, the discovery of a level lower than the first and the unforeseen involution in the levels of reasoning, for discussions in future research, aiming at improving its adoption and structure.

Lima (2023) researched commercial games and their use in the final years of elementary school, adopting the Systematic Review as a methodology and concluding that the benefits brought by games are not restricted to cognitive aspects such as attention, memory, abstract thinking and decision-making. They also generate reflections in behavioral aspects, development of motor skills and socialization.

The Papers developed to date show a variety of themes and theoretical and practical approaches, emphasizing relevant topics in research in Mathematics Education. The highlights are History as a methodology in the textbook (curriculum material presented to teachers), cognition and visualization in Geometry (Souza, 2017; Vieira, 2017 and Silva, 2017), mapping (Silva, 2017; Lima, 2023) and the use of technologies (Souza, 2017; Lima, 2023), revealing challenges for the initial and continuing education of teachers. Table 2 below presents the dissertations developed and under development since the initial constitution of the CTDEM group:

Table 2

Master's Theses developed within the scope of CTDEM

Authors	Nature	Format	Title	Program	IES
Magalhães (2016)	Academic Master's Degree	Monograph	The prescription and implementation of the Sesi Mathematics Room from the perspective of Trends in Mathematics Education	Postgraduate Degree in Teaching	UFF
Cruz (2016)	Academic Master's Degree		A plethora of polyhedra: exploring regular polyhedra with the methodology of Didactic Engineering		
Tostes (2017)	Academic Master's Degree		Proposal for using the Flubaroo Complement for assessment in Analytical Geometry: a case study.		
Souza (2020)	Academic Master's Degree	*Multipaper*	Digital Technologies for Teaching Geometry in the BNCC: positions made available to teachers and possible resistance		
Pereira (2020)	Academic Master's Degree		The BNCC of Mathematics, Cartographies: from the creation process to the context of practice in the Final Years of Elementary School.		
Perrone (2024)	Professional Master's Degree		Mind Maps as a Resource for Learning Plane Geometry in the Post-Pandemic Era	Postgraduate Degree in Science and Mathematics Education	UFRRJ
Brasil (2025)	Professional Master's Degree		Creativity and Problem Solving: Teaching Mathematics through Programming Logic		

Cruz's study (2016) presented a discussion about the teaching of Geometry based on curricular guidelines for High School (H.S.) and Professional Education, analyzing contributions of the software Uma Pletora de Poliedros for the appropriation of the Regular Polyedros concept. The experiment was carried out at the Instituto Federal Fluminense (IFF), Santo Antônio de Pádua campus, in the 1st year of Technical Education Integrated with H.S. The methodology was Didactic Engineering (Artigue, 1988), bringing reflections in the four phases in which it was found that spatial visualization, exploration of the software and the dynamism of the process contributed to the understanding of the concepts.

Magalhães's research (2016) analyzed the prescribed document of the SESIeduca methodology used in the SESI Mathematics Classrooms implemented in the Rio de Janeiro State Education Network, verifying how the proposal incorporates trends in Mathematics Education. Vergnaud's Theory of Conceptual Fields was used as a reference. The main collection instruments were the questionnaire, submitted to the coordinator and director of the SESI/Rio Mathematics Department, and the collection of books Concepts and Practices

published in the year the rooms were implemented. It was concluded that the proposal incorporates trends, such as History of Mathematics, Contextualization, Problem Solving, Error Valuing and use of Concrete Materials. The presence of interdisciplinarity and the possibility of using the technological resources of the Room to work on Hybrid Teaching were also evidenced.

Tostes' dissertation (2017) carried out a Case Study research with Mathematics teachers from the High School and Normal Course of a public school in the city of Itaperuna/RJ. The objective was to encourage the use of digital technologies and analyze the contributions of the Flubaroo Complement, with its tools and potential, to the practice of assessment. To analyze professional development, the Didactic Engineering developed by Artigue (1988) was adopted as the research methodology, where the creation of didactic situations developed by the participants in the experimentation was recorded, the comparison of the a priori and a posteriori analyses, verifying the initial questions and analyzing the validation of the phases and enabling discussions around the use of digital technologies, bringing contributions to the practice of assessment.

The research developed by Souza (2020) adopted rhizomatic cartography to conduct a study on the BNCC, analyzing the positions of educational entities, such as the Brazilian Society of Mathematical Education (SBEM), among others, which circulated during the homologation process. It was found that regimes of truths arising from the BNCC and that contemporary reforms have regimes with a propensity for the market, adapting to interests other than educational ones. The positions of teachers in the final years of E.S. in the municipality of Santo Antônio de Pádua-RJ were mapped, bringing reflections to curriculum acts with the adoption of digital technologies from the perspective of Creative Insubordination (D'Ambrósio and Lopes, 2015) and seeking lines of escape from the BNCC in the Geometry unit in the contexts of practice.

Still on the BNCC movement, Pereira's research (2020) mapped the process of elaboration and arrival in school contexts of the BNCC through a qualitative methodology with a cartographic bias linked to a process that involved changes, adaptations, ruptures and uncertainties. Changes in relation to the contents were studied with the insertion of the voices of four teachers from a municipal network, proposing paths for the exercise of autonomy through the concept of Creative Insubordination (D'Ambrósio and Lopes, 2015), highlighting clues that curricular reforms may be involved in interests outside the educational environment, assigning specific roles to the teacher and the student.

Perrone's research (2024) analyzed the contributions of mind maps to meaningful learning for 1st year high school students in a post-pandemic context. The work adopted the Systematic Review and Ausubel's (1978) theory of meaningful learning, which supported the proposition, application and validation of an Activity Guide with the aim of approaching knowledge objects, such as triangles and similarity through mind maps to approach trigonometry.

Brasil (2025) presents an investigation on the relationship between computational thinking and problem solving, focusing on the inclusion of algorithmic resolution, bringing a systematic review carried out in the CAPES repository and a proposal for a didactic sequence with students of the mathematics course at UFRRJ who are or have been part of PIBID. After validation, this systematic review will result in an educational product in the form of an Activity Book to promote the development of PC through unplugged activities in Mathematics classes in Basic Education.

The dissertations developed within the scope of PPGEn (UFF) and PPGEduCIMAT (UFRRJ) also highlight the group's concern with actions in different contexts: Elementary Education (Pereira, 2020; Santos, 2020; Magalhães, 2016), High School (Cruz, 2016; Magalhães, 2016; Perrone, 2023), Mathematics undergraduates (Brazil, 2025) and Continuing Teacher Training (Tostes, 2017; Pereira, 2020; Santos, 2020). The variety of themes is also evidenced, but with prevalence in research on curricular development in the Geometry unit (Santos, 2020; Cruz, 2016; Tostes, 2017; Perrone, 2023), involving digital curricular materials (Cruz, 2016; Magalhães, 2016; Tostes, 2017; Pereira, 2020; Santos, 2020; Perrone, 2023), concrete materials (Cruz, 2016; Magalhães, 2016) and unplugged activities for the development of computational thinking (Brasil, 2020) in Basic Education. Studies carried out in initial and continuing teacher training revealed difficulties in adherence to participation, which demands strategies to obtain significant samples for the studies developed and under development.

Table 3

Scientific Initiation Guidelines developed within the scope of CTDEM

Students	Project Title	Financing	IES
Santos (2019-2020)	Implementation of the BNCC in the Northwest Fluminense region: Professional Development and Digital Technologies in Mathematics Education	PIBIC/UFF	UFF
Cardoso (2022-2023)	Mind Maps as a teaching, learning and assessment tool in Mathematics in the Early Years of Elementary School	PIBIC/CNPq	UFRRJ
Cardoso (2023-2024)	Word clouds and mind maps as tools for recording and reflecting on the training of undergraduate students in the context of the PIBID/Mathematics/IM core of UFRRJ		
Cortes and Pereira (2024-2025)	Curricular and extension development for Mathematics Teaching in the Mathigon environment		
Nascimento (2022-2024)	Mind Maps as a resource for teaching, learning, assessment and self-assessment in Mathematics in the Final Years of Elementary School	PIBIC/FAPERJ	

The study by Santos (2019-2020) – a PIBIC/UFF scholarship holder – focused on the BNCC, bringing perspectives for the development and construction of Mathematics curricula with indications for the use of technologies. Activities on functions were structured in the Geogebra software, considering skills for E.M., with Creative Insubordination (D'Ambrósio and Lopes, 2015) as a theoretical lens in order to promote greater teacher autonomy in reflection processes. A workshop was held during the CTDEM Conference in 2019, where participants demonstrated a lack of knowledge about the BNCC; most were familiar with the software. Even those with difficulties in using it, recognized that it has enriching potential for their practices

Cardoso's IC (2022-2023) – PIBIC/CNPQ scholarship holder – analyzed the adoption of Mind Maps as a teaching tool for learning and assessment in Mathematics by students on the Pedagogy and Mathematics courses at IM/UFRRJ. Mind maps were analyzed as a pedagogical tool in two semesters of the Mathematics Teaching discipline, helping in the reflections on their processes in/for training, in the connections with previous knowledge objects for the continuity of the contents, and recognized that the maps can be configured as an important tool in their future professional practices.

The Nascimento research (2022-2024) – PIBIC/Faperj scholarship holder – brought results from a mapping of research and a pedagogical intervention that addressed the adoption of mind maps as a tool in Mathematics Teaching. The results highlighted gaps in the approach of mind maps in Mathematics Teaching in Elementary School; the scarcity of research and trends based on research found, and qualitative methodological choices involving maps. The

research also carried out a pedagogical intervention through the implementation of an extension course for teachers that proposed the dynamization of applets developed in GeoGebra for the Geometry approach. At the end of the course, the construction of a Mind Map was requested, which allowed the visual analysis of the reflections developed in the process of handling the activities, configuring itself as a significant tool for the evaluation and self-evaluation process in Mathematics.

Studies by PIBIC/CNPQ scholarship holder Cardoso (2023-2024) analyzed how Mind Maps and Word Clouds can assist in Teaching and Learning in Mathematics, considering records of both in PIBID members' portfolios. The Mind Maps produced were quite diverse, with the majority being related to knowledge objects, for reviewing content, compiling objectives and the methodologies adopted by the group, building creative and comprehensive representations of the themes.

Still under development, the project by Cortes – PIBIC/CNPQ scholarship holder and Pereira – volunteer (2024-2025) – aims to meet the demand for curricularization of extension, which is configured as a dimension that can articulate teaching and research, strengthening the joint construction of knowledge with society. In this sense, the project aims to build didactic sequences and applets in Mathigon, which will allow teaching processes in an interactive way, using strategies and resources, such as observation of patterns and experiments using tools from the environment.

The IC projects developed and under development within the group emphasized the creation of didactic sequences with digital curricular materials such as Geogebra in different pandemic and post-pandemic contexts in continuing teacher training (Santos, 2020; Nascimento, 2024). In addition to the studies of the aforementioned authors, the adoption of the mental map resource by undergraduate students in Pedagogy (Cardoso, 2023) as a tool for recording the productions of the PIBID/Mathematics/IM project at UFRRJ (Cardoso, 2024) was also evidenced. The low adherence to continuing education proposals was also evidenced in the projects, a challenge for the project by Cortes and Pereira (2025) that aims to meet the demand for curricularization of extension in initial training and contribute to the professional practices of teachers in service in Baixada Fluminense.

Meta-analysis and repercussions of the research developed

The meta-analysis was divided into Papers, Dissertations and Scientific Initiation and Repercussions, each of them generating subcategories from convergences in theoretical-methodological aspects contained in the research developed at CTDEM. The papers are

subdivided into the following subcategories: History of Mathematics (Table 4), Teacher Conceptions in Initial Training (Table 5), Levels of Geometric Thinking (Table 6) and Games (Table 7).

Souza's research (2016) was the first paper developed by the group, bringing together PNLD criteria and the vision of researchers to analyze how History is configured as a methodological resource in the 6th grade Mathematics books in elementary school, concluding that most of them present a synthetic story about the emergence of a certain concept. The research was supported by the PCN at the time the first version of the BNCC was released, which mobilized researchers, scientific societies and teachers of all levels and modalities; consequently, CTDEM research.

Table 4

Paper focusing on recursion in the History of Mathematics

Author	Research Data	References for analysis	Methodology	Knowledge objects
Souza (2016)	Textbooks	PNLD PCN	Qualitative	Mathematical Knowledge Objects for the Final Years of Elementary and Middle School

The Cortes' paper (2025) – still in the definition phase – aims to analyze the conceptions and knowledge of PIBID/Mathematics/IM/UFRRJ students (Announcement 2022-2024) elucidated in the final reports and portfolios, categorizing aspects related to the importance of PIBID in the articulation of theory and practice, planning, emphasis on the curriculum, didactic and methodological strategies, and relationships between the actors (coordinating professor at the university, supervising professor at the field school, course colleagues and students at the field schools).

Table 5

TCC focusing on the conceptions of teachers in initial training

Author	Participants	Collection instruments	Knowledge objects	Educational Processes
Cortes (2025)	Future Mathematics Teachers	PIBID Core Reports	Mathematical knowledge objects for the final years of elementary and middle school.	Portfolios

Regarding the research that addressed the levels of geometric thinking, it became possible to identify the focuses in their approaches, making it possible to highlight differences and peculiarities (Table 6):

Table 6

Papers on Geometric Thinking

Author	Participants/Database	Collection instruments	Knowledge objects	Educational resources	Educational Products/ Processes
Souza (2017)	Students of the Bachelor's Degree in Mathematics at UFF/INFES	Questionnaire	Plane Geometry	Geogebra *(on line) and Scratch (offline)*	Computational game
Vieira (2017)	GT09 - Working Group on Cognitive and Linguistic Processes in Mathematics Education	Systematic Review	Geometry	Not applicable	Not applicable
Silva (2017)	Annals of the National Meetings on Mathematics Education of the 21st century				

Souza (2017) used a computer game for experimentation, analyzing the Van Hiele levels of students entering the mathematics course at UFF/INFES. Vieira (2017) mapped research groups and actions of GT 09 of SBEM that specifically addressed issues related to cognition using the Van Hiele Silva Model (2017). This is a mapping of all the work of the National Meetings on Mathematics Education (ENEM) held in the 21st century, which used the Van Hiele Model, kicking off the adoption of systematic mappings carried out in research by the CTDEM group, to identify gaps and trends.

Regarding games, in addition to the work of Souza (2017), Lima (2023) carried out a systematic review of commercial games and their use in educational contexts in different areas, highlighting potential for the development of cognitive motor skills, behavioral and socialization aspects.

Table 7

Papers about Games

Author	Participants/Database	Collection instruments	Knowledge objects	Educational resources	Educational Products/ Processes
Lima (2023)	*Google Scholar*	Systematic Review	Different areas of the Final Years of Elementary School.	Commercial Games	Not applicable
Fernandes (2025)	Students in the Early Years of Elementary School.	Workshop	Science and Mathematics Knowledge Objects for the Early Years of Elementary School	Non commercial Games	RPG Game

Fernandes' work (2025), still in the maturation phase, aims to build a game based on RPG models for the development of skills, showing scientific and mathematical literacy in the Early Years of Elementary School.

Master's Dissertations

In this section, a meta-analysis (Alencar and Almouloud, 2017 apud Kiefer and Mariani, 2021) of the dissertations presented will be carried out according to the following subcategories: Didactic Engineering (Table 8), Rhizomatic Cartography and Creative Insubordination (Table 9); Conceptual Fields (Table 10), and Ausubel's Production of Meanings (Table 11).

The results listed in Table 8 – below – show that the studies by Cruz (2016), Tostes (2017) and Brasil (2024) adopted questionnaires for data collection – before and after the didactic moment. The research by Cruz (2016) and Tostes (2021) analyzed the data obtained with the elaboration of categories from the perspective of Bardin's (2016) content analysis, highlighting an emphasis on teaching, learning and assessment in Geometry and research gaps that appropriate Didactic Engineering in the initial and final years of Elementary School.

Table 8

Master's Dissertations developed at CTDEM using Didactic Engineering

Author	**Participants**	**Collection instruments**	**Knowledge objects**	**Educational resources**	**Educational Products**
Cruz (2016)	Students of the Technical High School of IFF/Pádua	Questionnaire and Interviews	Spatial Geometry	Plethora of Polyhedra (online)	Didactic Sequence
Tostes (2017)	Teachers from the state network of Miracema-RJ	Closed questionnaire and Open questionnaire.	Analytical Geometry	*Graphing Calculator* (Geogebra)/ Flubaroo Complement *(online)*	Tutorial e atividades com o Complemento *Flubaroo*
Brasil (2024)	Students of PIBID/Mathematics/UFRRJ	Questionnaires / mini-course	Geometry, Algebra and Logic	Unplugged activities on programming logic	Didactic Sequence

Regarding the studies that adopted cartography and Creative Insubordination, Souza (2020) focused on the BNCC Geometry skills on the use of digital technologies, and structured applets to work with teachers. Pereira (2020) studied the implementation of the BNCC, bringing an activity on 1st-degree polynomial function. Both studies, from the perspective of Creative Insubordination, mapped discourses (Deleuze, 2005) that gave clues about intersections in their curricular experiences, making it possible to find loose threads that leave room for the autonomy of the teacher who – in fact – is the protagonist of the curricular construction and

practice, where it is necessary to “be aware of when, how, and why to act against established procedures or guidelines” (D’Ambrosio and Lopes, 2014, p. 29).

Table 9

Dissertations that used Cartography and Creative Insubordination as theoretical-methodological references

Author	Participants	Collection Instruments	Knowledge objects	Educational resources	Educational Products/Processes
Souza (2020)	Teachers in the Final Years of Elementary School	Interviews	Plane Geometry	*Geogebra*	Applets to move/ Creative Insubordination Scenes
Pereira (2020)	Teachers in the Final Years of Elementary School	Interviews	1st Degree Polynomial Function	*Geogebra*	Creative Insubordination Scenes

Regarding Vergnaud's (1993) theory of Conceptual Fields, Magalhães (2016) adopted the theoretical lens to point out trends in Mathematics Education at Sala Sesi, highlighting the importance of students explaining their previous conceptions, as these are composed of theorems-in-action and concepts-in-action that – if worked correctly – can evolve into scientific knowledge.

Table 10

Dissertations developed from the perspective of the Theory of Conceptual Fields

Author	Participant	Collection Instruments	Knowledge objects	Educational resources	Educational Process
Magalhães (2016)	Coordinator and director of the Mathematics Department at SESI Rio	Questionnaires	Mathematics Curriculum for Basic Education	Sesi/ Mathematics Room Resources	Analysis of the book collection “Concepts and Practices” from the Sesi classrooms from the perspective of Trends in Mathematics Education.

Regarding Meaningful Learning, Perrone (2024) used Ausubel's (1978) lenses. These argue that learning occurs when new information relates in a non-arbitrary way to what is already present in the cognitive structure. In this context, the maps created by the students proved useful in understanding concepts, demonstrating the potential for creativity and engagement, making Geometry Teaching more meaningful.

Table 11

Dissertation developed from the perspective of the Theory of Meaningful Learning

Author	Sample	Collection Instruments	Knowledge objects	Educational resources	Educational Product
Perrone (2024)	Teacher and students of the 1st year of high school at Seeduc-RJ	Interview and construction of Mind Maps	Plane Geometry	Mind Maps	Activity Guide[2]

Scientific Initiation (IC)

The IC works were divided into the following categories regarding resources: Mind Maps (Table 12) and Digital Environments (Table 13):

Table 12

IC research that adopted Mind Maps in isolation or in combination

Students	Sample	Collection Instruments	Knowledge objects	Educational resources	Educational Processes
Cardoso (2022-2023)	Students of Pedagogy and Mathematics courses in the subject Teaching Mathematics	Mind Maps	Thematic units in the area of Mathematics	Mind Maps	Catalog
Nascimento (2022-2024)	Mathematics Teachers for the Final Years of Elementary School in Baixada Fluminense	Questionnaires and Mind Maps	Plane Geometry	Geogebra and Maps	Catalog/Extension Course
Cardoso (2023-2024)	Students of the Mathematics Degree course at IM/UFRRJ participating in Pibid	Electronic Portfolios	Thematic units in the area of Mathematics	Mind Maps and Word Clouds	Catalog

Cardoso (2022-2023) and Nascimento (2022-2024) used both systematic review and qualitative-quantitative research to analyze the Mind Map approach throughout the Elementary School. (Cardoso, 2022-2023) with records of students in initial training and Nascimento (2022-2024) within the scope of continuing teacher training. Cardoso (2023-2024) also analyzed the word clouds in the portfolios of PIBID students. These studies revealed gaps, trends, and peculiarities with the adoption of these resources, which proved to be potentially rich for the production of meanings in teaching, learning, and in initial and continuing teacher training processes. As for the studies that involved the use and exploration of digital environments, Table 13 below illustrates some scenarios:

[2] Educational Product available at: https://educapes.capes.gov.br/handle/capes/917229

Table 13

Scientific Initiation Research in Digital Environments

Students	Sample	Collection Instruments	Knowledge objects	Educational resources	Educational Products
Santos (2019-2020)	Mathematics Teachers from the Northwest Fluminense Region	Geogebra records and questionnaires	Polynomial Functions	*Geogebra Classroom*	*Applets*
Cortes e Pereira (2024-2025)	Mathematics Teachers from Baixada Fluminense	Mathigon Records and Questionnaires	Mathematics Thematic Units	*Mathigon*	Mathigon Tutorial and Teaching Sequences

The studies by Santos (2019-2020) and Cortes and Pereira (2024-2025) focused on the implementation of the BNCC, bringing perspectives for the development of skills and construction of curricula, aiming to meet the demand for curricularization of extension, with the construction of cards containing didactic sequences in the Geogebra and Mathigon environments respectively, allowing the planning of processes in an interactive way with digital resources in the initial and continuing education of teachers.

In the next section, the results of the research at the undergraduate, Master's and IC levels developed in these ten years of activity of the CTDEM Group will be highlighted.

Repercussions of the CTDEM group

The actions and research carried out within the scope of CTDEM generated impacts and repercussions, which were divided into the following categories: Funding (Table 14), Organized Events (Table 15), Articles (Table 16), and Books and Chapters (Table 17):

Proposals for funding were submitted, where CTDEM was awarded resources from the following notices:

Table 14

Funding received by CTDEM

Notice Title	Project Title	Funding Body	Year
Research Promotion Program (Fopesq 2017)	Dialogues on the implementation of the BNCC in the Northwest Fluminense Region: levels and types of education.	PROPPI/UFF	2017
APQ1- Support for Basic Research	Creative Insubordination in the Teaching of Mathematics for the Final Years of Elementary School through Technologies: Challenges of Implementing the BNCC	FAPERJ	2019

Granting of Financial Support to Research Groups	Production of articles, e-books and consumable materials within the scope of CTDEM actions	PROPPG/UFRRJ	2023
Support for Scientific Events	Ten-year journey of the CTDEM Research Group	FAPERJ	2024
Notice for Mathematics in the Final Years of Elementary School	Geometry Skills from the National Curricular Common Base (BNCC) for the Final Years of Elementary School with the help of digital resources and concrete materials developed by Teachers from Baixada Fluminense	Itaú Social in partnership with the Basic Education Secretariat of the Ministry of Education and Culture (MEC)	2025

The Research Promotion Program (FOPESQ) seeks to meet the emergency needs of researchers and research groups. This is a UFF initiative that provides an opportunity to better understand its researchers and their demands.

The APQ1 2019 Call for Proposals from Faperj promoted the project "Creative Insubordination in Mathematics Teaching for the Final Years of Elementary School through Technologies: Challenges in Implementing the BNCC", mobilizing dissertations by Souza (2020), Pereira (2020) and Nascimento (2022-2024). The project culminated in the e-book entitled "Autonomous curricular practices in teaching geometry through digital technologies", which brought the proposal for an extension course through GeoGebra Classroom, where teachers obtained reflections on some aspects, such as investigation, elaboration and resolution of problems with different strategies through applets from the perspective of Creative Insubordination (Lopes; D' Ambrósio, 2015) for the critical approach of geometric skills.

Based at IM/UFRRJ, the CTDEM group was selected through the Notice for Proposals for Financial Aid to Support Research Groups Led by Postgraduate Professors promoted by the Pro-Rectory for Research and Postgraduate Studies (PROPPG) of UFRRJ, enabling the production of articles, e-books and consumable materials.

The Itaú Social Notice aims to promote innovative learning projects in public schools between the 6th and 9th grades of Elementary School and, throughout 2025, training meetings will be proposed with teachers from Baixada Fluminense to promote and build geometric concepts with digital and concrete curricular materials. The CTDEM ten-year journey was submitted to FAPERJ Notice No. 20/2024 – Support Program for the Organization of Scientific, Technological and Innovation Events in the State of Rio de Janeiro for events in 2025. The

proposal was approved in TRACK A: Scientific and technological event projects, and the aspirations will be described below.

The complete list of events organized by the group is shown in Table 15 below.:

Table 15

CTDEM scientific events

Modality	**Title**	**Year**	**Location**
Seminars	Curriculum Development, Teacher Training and Technologies in Mathematics Education	2016	UFF/INFES
		2017	
Conference	National Science and Technology Week (SNCT)	2016	
		2017	
		2019	
Scientific Exhibition	Language, Science and Mathematics Circuit	2023	UFRRJ/IM
Scientific Exhibition	CTDEM Group Actions: Trajectory and Perspectives (SNCT)	2024	
Conference	Ten years of the CTDEM group (In press)	2025	

CTDEM organized two editions of the Seminar "Curricular Development, Teacher Training and Technologies in Mathematics Education", the last one with resources from the Fopesq Call (2017), making it possible to discuss research in the area of Education from interdisciplinary perspectives, thus integrating students and professors from UFF/INFES, teachers and students nationwide. The seminars included short courses, round tables and communications organized in working groups (GTs): GT1 – Mathematics Education; GT2 - Education and Training; GT3 – Educational Psychology.

The CTDEM conferences, which took place during the SNCT and Academic Agendas of UFF (2016, 2017 and 2019), were important moments for the dissemination of research, the holding of short courses and the promotion of debates about the BNCC curricular reform movement, bringing together researchers and teachers from Basic Education.

The Language, Science and Mathematics Circuit held at SNCT (2023) – already in the context of IM/UFRRJ – allowed the group, PIBID students from the Mathematics course, residents from the Pedagogy course and master's students from PPGEduCIMAT, to analyze and discuss extension activities, highlighting the integration between the areas and the interaction

between the University and Basic Education through experiments, games and concrete materials, with a significant presence of students and teachers from the schools.

In 2024, the Scientific Exhibition "CTDEM Group Actions: Trajectory and Perspectives" was held at IM/UFRRJ, celebrating nine years and looking ahead to ten years of scientific communications, where participants recorded the main themes addressed, generating the following Word Cloud (Figure 1):

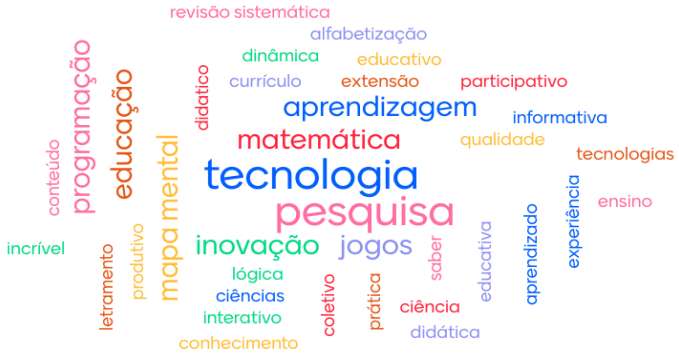

Figure 1.

Word Cloud for evaluating the CTDEM Exhibition at SNCT (2024).

The ten-year CTDEM Journey was approved via the Faperj Events Support Notice and is in the definition phase. So far, the event envisages moments such as: History and Posthumous Tributes, communication of completed and ongoing research, scientific communications in Working Groups (GTs) and a lecture by a professor from outside UFRRJ on the theme "Digital technologies, Mathematics curriculum, AIs and neoliberal policies in Education", presentation of research and future actions.

Still about disseminating the research developed within the group, several research were published in the form of articles in relevant journals in the area of Education, Mathematics Education and Teaching (Table 16):

Table 16

Scientific articles from research carried out within the scope of CTDEM

Author	Journal	Title
Cruz e Dias (2017)	GEPEM Bulletin	A Plethora of Polyhedra and the Methodology of Didactic Engineering: Enhancing the Teaching of Regular Polyhedra
Tostes e Dias (2017)		Potentialities of Touchscreen Technology for Teaching Mathematics
Souza e Dias (2019)	Mathematical Education Debate	A software for analyzing the development of geometric thinking according to the Van Hiele model
Souza e Dias (2022)	Perspectives in Dialogue: Journal of Education and Society	Implementation of the BNCC: possibilities of resistance in the use of Technologies in the Teaching of Geometry.

Souza e Dias (2020)	Curriculum Space	The BNCC and the use of digital technologies in Mathematics Education: discourses on curricular reform.
Silva e Dias (2020)	Science and Mathematics Teaching (REnCiMa)	Van Hiele's Geometric Model: State of the Art in the National Meetings on Mathematics Education (ENEM)
Souza e Dias (2020)	Scientific Interfaces – Education	Subject positions demanded by Digital Technologies in Mathematics Education.
Pereira e Dias (2021)	@mbienteeducação	The BNCC of Mathematics for the Final Years in the context of practice: possibilities of teacher autonomy
Tostes e Dias (2023)	Paradigm	The Google Flubaroo Add-on as a proposal for an assessment tool in Analytical Geometry
Nascimento e Dias (2024)	Sergipe's Journal of Mathematical Education (Revisem)	Mind Maps as a Tool for Teaching, Learning, Assessment and Self-Assessment in Mathematics in the Final Years of Elementary School
Lima e Dias (2024)	Convergences: Studies in Digital Humanities	Systematic Review of the Literature on Commercial Games as a Didactic Resource in the Final Years of Elementary School
Perrone e Dias (2024)	Ensin@ UFMS Journal	Thematic Unit Geometry in High School: A Systematic Review on the Adoption of Mind Maps.
Cardoso e Dias (2024)	Dialogues in Mathematical Education Journal	Teaching and assessment in Mathematics in the initial years with the resource of Mind Maps: record and reflections in a context of teacher training.

The articles by Souza and Dias (2019); Silva and Dias (2020) were published in editions of Fluxo Contínuo. The articles by Tostes and Dias (2017), Silva and Dias (2017) were published in a special edition of the Gepem Bulletin, containing papers from the VIII Seminar on Research in Mathematics Education in Rio de Janeiro (SPEM-RJ) in 2016.

The article by Souza and Dias (2022) was part of the dossier "Struggles and Resistances in Michel Foucault" and the article by Souza and Dias (2020) of the dossier "Curriculum: creations and (re)insurgency".

The article by Souza and Dias (2020) was part of the editorial "Mathematical Education in teaching and learning contexts through Digital Information and Communication Technologies (TDIC)" and the article by Pereira and Dias (2021) was part of the dossier "The mobilization of the concept of creative insubordination in research in education".

The article by Tostes and Dias (2023) was part of the Thematic Issue "Evaluation in Mathematical Education" and the article by Nascimento and Dias (2024) was part of the Thematic Issue "Evaluation in Mathematics: Challenges and Possibilities". The article by Lima and Dias (2024) was part of the dossier "Electronic games and video games as a field of study".

The article by Perrone and Dias (2024) was published in Fluxo Contínuo and the article by Cardoso and Dias (2024) in the thematic dossier entitled "The training of the pedagogue to teach Mathematics: curriculum and practices".

The survey shows that most of the articles were published in dossiers that converged with emerging demands and with the research developed by the CTDEM Group, addressing

topics such as Digital Technologies, Teacher Training, Curriculum, Assessment and Insubordination.

Some research was also published in the form of books and chapters, as shown in Table 1.

Table 17

Books and Chapters from research carried out within the scope of CTDEM

Authors	Nature	Publisher	Title
Cruz e Dias (2020)	*Free E-book*	Fi	Spatial Geometry with the free software "A Plethora of Polyhedra": cuts, plans, elements and operations.
Tostes e Dias (2023)	Physical Book and E-book	Multifoco	Mathematics assessment using the Flubaroo device.
Dias, Nascimento e Cardoso (2024)	Book Chapter	Universidade Rural (Edur)	Mental Maps for teaching Geometry in Elementary School: Systematic Review and Pedagogical Intervention.

The e-book by Dias and Cruz (2020), based on Cruz's research (2016), reflects on the use of the A Plethora of Polyhedra software and was launched during the Covid-19 pandemic at the remote event I International Meeting of the Postgraduate Program in Teaching (I EIPPGEn) of UFF/INFES. The book presents an experiment at IFF Pádua, configuring itself as an example of how to articulate content, time, dynamics, approach in textbooks, a priori and a posteriori conception, and dialogic relationship between objectives and resources in the design and implementation of technology-mediated classes.

The book and e-book by Tostes and Dias (2023), the result of Tostes' research (2017), was launched during the live Assessment in Mathematics promoted by Fundação Cecierj and brought the pedagogical experience with the Didactic Engineering methodology (Artigue, 1988) with the participation of teachers in a public school. The authors discuss and show how the act of evaluating goes beyond checking, placing students in a more critical and autonomous position, since – by analyzing their results – they can reflect on their own mistakes and successes, understanding the relevance of both in their learning process.

As a result of the meta-analysis of the work carried out and its repercussions, below (Figure 2) is the Mind Map of the research over these ten years:

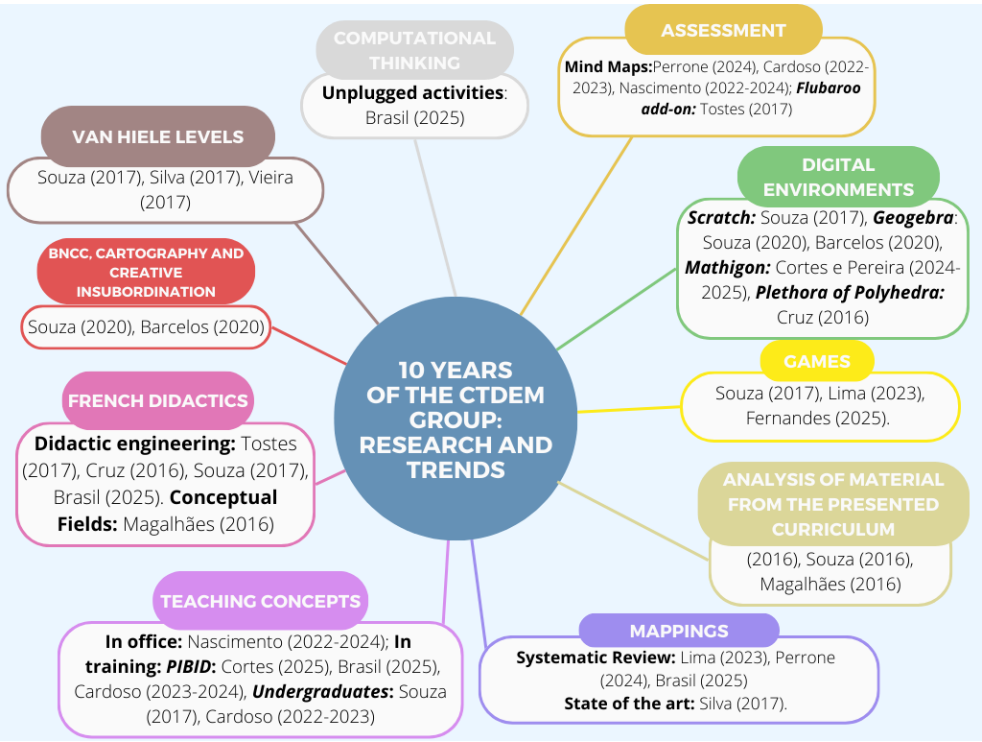

Figure 2

Research carried out in a decade by the CTDEM group

The meta-analysis highlights the emphasis of research developed by the CTDEM Group in digital environments, theoretical-methodological lenses of French Mathematics Didactics, especially Didactic Engineering, and analyses of teaching concepts in initial and continuing education. As perspectives, more research approaches on plugged and unplugged activities are envisaged, including involving the so-called generative AIs to map at what moments it may be possible to establish the relationship between Mathematics teaching and Computational Thinking, considering the specificities of these fields of knowledge.

Final considerations

In the final stages, it became possible to demonstrate that the research developed within the scope of CTDEM brought contributions and trends in methodology. These enhanced the analysis of data carried out at different levels and training processes, allowing the group to immerse themselves in various contexts of practice, generating reflections that contributed to the planning of teaching situations.

Didactic Engineering played a leading role in the research carried out at CTDEM, bringing repercussions on the analysis of the prescribed curriculum, on the analysis of the preliminary version of the BNCC (MEC, 2016) and on the approved document (MEC, 2018).

This allowed problematizing and discussing competencies, skills and objects of knowledge of the thematic units and highlighting processes of improvement in learning and restudy of concepts, making it possible to confirm the various hypotheses raised in the a priori analysis phase of these research. As contributions to future research to be developed in the context of the CTDEM group, in addition to teaching adopting digital technologies through plugged and unplugged activities, comparative analyses of theoretical and methodological perspectives in national and transnational prescribed curriculum documents are envisaged. It is also intended to develop materials from the presented curriculum (such as the textbook) under different theoretical lenses at different historical moments (transition of curriculum reforms, preliminary versions, public consultations and incipient implementations).

The difficulty of teachers' adherence to continuing education proposals stands out, as well as the tendency to adopt multipaper, an insubordinate format that optimizes dissemination; mappings pointing out trends and gaps; the relationship between Computational Thinking and Mathematics; and the structuring of digital environments. The research helped identifying demands such as the focus on the Early Years of Elementary School and the impacts and challenges of Generative Artificial Intelligence (AI) in the curriculum. The identifications allow for the personalization of teaching and can give rise to formative experiences and innovative practices in Mathematics Education.

Finally, it is worth highlighting that this is an emerging theme not only within the scope of CTDEM, but that Education and Mathematics Education need to address challenges associated with the implementation of AI, such as data privacy, technological infrastructure, and teacher training (Medeiros et.al, 2024). The lack of familiarity with the tools and algorithms used demands additional efforts in training and continuous professional development (Borges, 2023), as well as combating the generation of fake news bubbles (Borba and Balbino Junior, 2023).

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