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Technological and Pedagogical Knowledge in initial mathematical training: elements for reflection

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ABSTRACT

It Digital Information and Communication Technologies (TDIC) are increasingly present in the school environment and also in several studies focused on the teaching practice and the implications of the use of TDIC in the teaching and learning processes. The understanding of Technological Pedagogical Content Knowledge (TPACK) supported by the Knowledge Base detailed by Lee Shulman (1986, 1987), more specifically the Pedagogical Content Knowledge, in the international literature Pedagogical Content Knowledge (PCK), provides elements to reflect on the knowledge inherent to the teacher who uses TDIC for pedagogical purposes. A systematic review of the literature was performed (Brizola and Fantin, 2016; Galvão and Ricarte, 2019 and Campos, Caetano and Laus-Gomes, 2023) in the search for a theoretical framework regarding the practices on the use of Digital Information and Communication Technologies (TDIC). The documental corpus consists of 7 works from the Brazilian Digital Library of Theses and Dissertations (BDTD), 2 theses and 5 dissertations. In the process of delimiting the Analysis Categories, the Atlas.ti software was used. The studies analyzed indicated that the process of appropriation of the use of technologies in education by future teachers corroborates Shulman's (1986, 1987) propositions about the knowledge base for teaching, which is composed of a set of knowledge arising from training, experiential learning and knowledge constructed in interaction with peers. Therefore, the need for a solid articulation between initial training and continuing education of teachers is emphasized, so that both are aligned with the perspective of a digital culture and promote the development of reflective attitudes towards TDIC and its implications in daily school life. The results of the research pointed to the close connection between initial and continuing education, so that an initial education that ignores the technological potential in teaching tends to generate future resistance on the part of teachers.

Keywords: Teacher training, digital culture, mathematics degree, education, teaching knowledge.

Conhecimento tecnológico e pedagógico na formação inicial em matemática: elementos para uma reflexão

RESUMO

As Tecnologias Digitais da Informação e Comunicação (TDIC) estão cada vez mais presentes no ambiente escolar e também em diversos estudos que focam a prática docente e as implicações da utilização das TDIC nos processos de ensino e aprendizagem. A compreensão do Conhecimento Tecnológico e Pedagógico do Conteúdo ou Technological Pedagogical Content Knowledge (TPACK, na sigla em inglês) apoiada na Base de Conhecimentos detalhada por Lee Shulman (1986, 1987), mais especificamente o Conhecimento Pedagógico do Conteúdo, na literatura internacional Pedagogical Content Knowledge (PCK), fornece elementos para refletir sobre os conhecimentos inerentes ao docente que utiliza TDIC para fins pedagógicos. Foi realizada uma revisão sistemática da literatura (Brizola e Fantin, 2016; Galvão e Ricarte, 2019 e Campos, Caetano e Laus-Gomes, 2023) utilizando para a análise dos resultados a Análise de Conteúdo (Bardin, 1977; Rodrigues, 2019) na busca de um arcabouço teórico a respeito das práticas sobre o uso de Tecnologias Digitais da Informação e Comunicação (TDIC) nos currículos dos cursos de Licenciatura em Matemática que permitisse contribuir para o enfrentamento do desafio de aproximar a educação matemática e a tecnologia. O corpus documental é composto por 7 trabalhos oriundos da Biblioteca Digital Brasileira de Teses e Dissertações (BDTD), sendo 2 teses e 5 dissertações. No processo de delimitação das Categorias de Análise, foi utilizado o *software* Atlas.ti. Os trabalhos analisados indicaram que o processo de apropriação do uso de tecnologias na educação pelos futuros professores, corrobora as proposições de Shulman (1986, 1987) sobre a base de conhecimento para docência que é composta por um conjunto de saberes decorrentes da formação, do aprendizado experiencial e saberes construídos na interação com seus pares. Portanto, enfatiza-se a necessidade de uma sólida articulação entre a formação inicial e a formação continuada de professores, de maneira que ambas estejam alinhadas à perspectiva de uma cultura digital e promovam o desenvolvimento de posturas reflexivas frente às TDIC e suas implicações no cotidiano escolar. Os resultados da pesquisa apontaram para a estreita ligação entre formação inicial e continuada, de modo que uma formação inicial que ignore o potencial tecnológico no ensino tende a gerar resistências futuras por parte dos professores.

Palavras-chave: Formação de professores, cultura digital, licenciatura em matemática, educação, conhecimento docente.

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INTRODUCTION

The emergence of Digital Information and Communication Technologies (TDIC), as well as the daily contact with them, resulted in significant changes in the ways of living, studying and working in modern society (Kenski, 2003). It is evident that, among the various social sectors affected by the presence of TDIC, education was not an exception, on the contrary, educational institutions became spaces responsible for education with and for these technologies (Scherer; Brito, 2020).

Included in this scenario, teachers need to have the opportunity to live with digital technologies from the starting moment of their initial training, so that they can get closer to this reality in which their students are increasingly connected with TDIC. In addition, contact with such technologies can provide teachers in training with a reorganization of their practices and, consequently, reflect on the learning of their students (Bragagnollo; Oenning; Souto, 2020).

In this perspective, the present work, derived from a research under development in the Graduate Program in Teacher Training and Interdisciplinary Practices, aims to analyze discussions and practices about the use of digital technologies in the curriculum of Mathematics Teaching Degree courses through a systematic review of the literature, following the principles listed by Brizola and Fantin (2016), Galvão and Ricarte (2019) and Campos, Caetano and Laus-Gomes (2023).

Thus, it was possible to define and filter a documental corpus of 48 theses and dissertations from the Brazilian Digital Library of Theses and Dissertations (BDTD) in order to be faithfully reproducible and verified, guaranteeing a high level of scientificity, as reinforced by Galvão and Ricarte (2019). Of the 48 studies initially selected, 7 were filtered after applying the inclusion and exclusion criteria. Next, the analysis of the filtered works was done, which occurred originating from the three phases of Content Analysis, proposed by Bardin (1977): pre-analysis, exploration of the material and treatment of the results.

This work is structured in seven sections, namely: the present introduction is the first; the second section deals with a small theoretical discussion about the curriculum

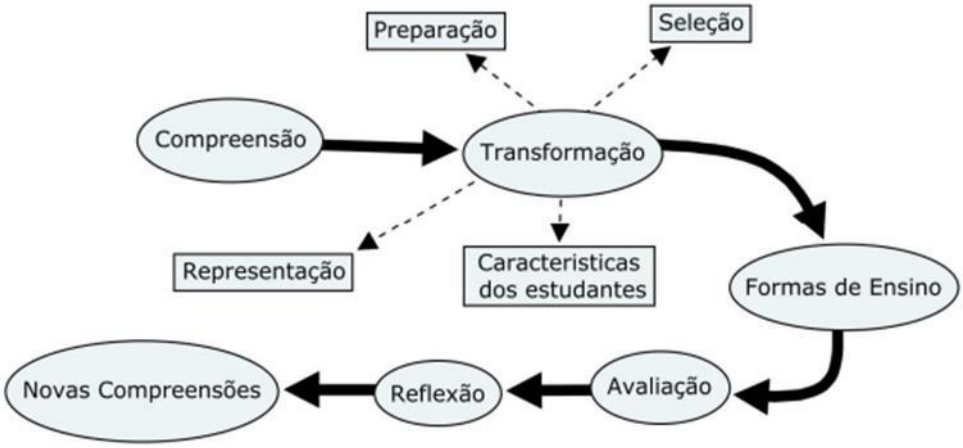
of the Mathematics Teaching Degrees and the integration of the TDIC; the third aims to address the challenges faced and possible strategies for the mentioned integration; the fourth presents a reflection on the theoretical categories of the Knowledge Base proposed by Lee Shulman for the understanding of teacher training; the fifth section consists of detailing the methodology composed of the Systematic Review of Literature and Content Analysis as supported by Bardin (1977); the sixth section presents and discusses the results found by the current investigation, according to the Categories of Analysis listed; and, finally, the seventh section, brings the final considerations of the article.

In 1986, based on studies done with starting and experienced teachers, Lee S. Shulman highlighted three theoretical categories of knowledge present in the cognitive development of teachers: content knowledge, pedagogical content knowledge and curricular knowledge. Later, in 1987, revised these categories, breaking them down into seven.

For the researcher, all categories are relevant and support the movement expressed in the model of action and pedagogical reasoning that will be explained next. However, it should be noted that, in his study, he emphasizes Pedagogical Content Knowledge (PCK), as the category that consecrates the presence of all the others in the teacher's work and expresses the individual ability that distinguishes even the teacher of a given discipline from a specialist of that discipline in a certain area of knowledge. In short, Pedagogical Content Knowledge is considered the specific professional knowledge of teachers.

In Shulman's (1986, 1987) model of Pedagogical Reasoning and Action, a contribution to the analysis of professional knowledge, the ideas of a professional knowledge base stand out, which have been studied and reformulated by different authors in order to systematize them in models that aim to analyze professional practice. In this model (Figure 1), the scholar sought to encompass the knowledge that the teacher has and its transformation during professional practice.

Figure 1: Pedagogical Reasoning and Action Model



Source: Adapted from Shulman (1987).

This model is interesting because it helps to understand how professional knowledge develops during the educational process and at each new cycle of action/reflection of the teacher, while outlining paths for the unveiling of how professional knowledge develops. Although this knowledge is individual and characteristic of each teacher, it is from this observation that reference models are reconfigured in the dimensioning of the curriculum of initial teacher education.

The expression, Pedagogical Content Knowledge, was first defined by Shulman at a conference at the University of Texas in 1983 with the title: "The Lost Paradigm in Teaching Research." At that event. Shulman defined lost paradigm the scarce attention that specific content was earning in teacher training. For Shulman (1986), PCK is a specific category of teachers' knowledge within the category of practical knowledge. Therefore, PCK construct refers to the intersection between content and pedagogy and supposes, in the researcher's original view, the competence demonstrated by a teacher to transform the knowledge of the content he has into forms pedagogically adapted to the specificities of the students, considering their repertoire. For Shulman (1987), it is this capacity for transformation that translates the pedagogical knowledge of the content, extrapolates specific knowledge and reaches the dimension of knowledge to teach. As Valente (2017) showed more recently in his study on the professionalization of the mathematical educator as opposed to the mathematics teacher, that the empirical basis of the history of Brazilian mathematics education is to consider "mathematics to teach" as its constitutive reference. From this perspective,

mathematics for teaching (pedagogical knowledge) reveals the autonomy of a new teaching knowledge that, in articulation with the mathematics to be taught (disciplinary knowledge), characterizes the teaching profession, giving it a professional identity.

METHODOLOGICAL PATH

The present study is a systematic review of the literature, although there is no single method to be followed to perform a systematic review of the literature, there is a common core in the methods created by different authors (Brizola; Fantin, 2016). Campos, Caetano, and Laus-Gomes (2023) also point out that, despite the variations in the steps suggested by different authors for this type of study, planning is an aspect on which there is a scientific consensus.

When planning a systematic literature review, it is important to develop a research protocol that represents the outline of the execution of each stage, with rigor and transparency as its characteristics. It is worth noting that the protocol, like the systematic literature review, does not have a standard or structure available (Campos; Caetano; Laus-Gomes; 2023).

Based on the guidelines of Galvão and Ricarte (2019), the present study followed the succeeding steps in its protocol: i) elaboration of the guiding question of the research; ii) selection of the database; iii) elaboration of the search strategy; iv) definition of inclusion and exclusion criteria; v) selection of papers; and vi) analysis of the results.

Starting from what was previously mentioned and what is intended with the objectives of this research, the following guiding question of this systematic review of the literature is defined: How the curriculum of Mathematics Teaching Degree courses incorporated discussions and practices on the use of digital technologies?

As a database, for searching the works to be analyzed by the research, the Brazilian Digital Library of Theses and Dissertations (BDTD) was selected, as it holds a wide range of productions by researchers from national teaching and research

institutions.

The search strategy, as guided by Galvão and Ricarte (2019), initially consisted of mapping search terms aligned with the research question, being inserted into the database with the following combination of Boolean operators: ("curriculum" OR "program" OR "syllabus") AND ("degree in mathematics" OR "mathematics course") AND ("digital technology" OR "educational technology" OR "technology in education").

As for the year of defense of the works found in the database, a period was not defined, since the present research intended to analyze all BDTD works, not limited to a period of time. Thus, a total of 48 studies were found to be submitted to the stage of the inclusion and exclusion criteria, which are presented in Table 1.

Table 1 - Inclusion and exclusion criteria

Criteria		**Description**
Inclusion	CI01	Theses and dissertations that address PPCs[1] and/or the flowcharts of the Degree courses in Mathematics and digital technologies
Exclusion	CE01	Duplicate works
	CE02	Theses and dissertations that address PPCs and/or the flowchart, but without presenting digital technologies in the Mathematics Degree courses
	CE03	Theses and dissertations that address digital technologies, but without presenting PPCs and flowcharts of the Mathematics Degree courses
	CE04	Theses and dissertations that are not available for download

Source: Prepared by the authors (2025).

After applying the inclusion and exclusion criteria to the titles and abstracts of the 48 works selected in the BDTD database, the papers were selected, with a total of 7 (2 theses and 5 dissertations). Finally, the final stage was the analysis of the results, based on the procedures of the Content Analysis proposed by Bardin (1977). Table 2 shows the information relevant to the papers.

Table 2 - Selected works for analysis

[1] PPC is the acronym for Pedagogical Course Project.

Code	Author	Type	Year	Program	Title
T3	SOUZA, Jediane Teixeira de	Dissertation	2008	Mathematics Education	Information and communication technologies in mathematics degree courses
T8	LOBATO, Lúcia Helena dos Santos	Dissertation	2003	Production Engineering	Informatics in education: mathematics and its teachers on the paths to a new school reality
T13	HERMENEGILDO, Késia de Mélo	Dissertation	2017	Mathematics Education	The knowledge of initial teacher training for the integration of research in mathematics with dynamic geometry resources
T14	COLLING, Juliane	Dissertation	2017	Education	Perspectives for the articulation of pedagogical, technological and content knowledge in the initial training of mathematics teachers
T24	MENEGAIS, Denice Aparecida Fontana Nisxota	Thesis	2015	Computing in Education	The continuing education of mathematics teachers: a technological insertion of the Khan Academy platform in teaching practice
T27	PACHECO, Edevaldo Gomes	Dissertation	2020	Mathematics	Use of technology in the training of mathematics teachers in the northern region of Brazil
T30	ARAÚJO, Wellington Alves de	Thesis	2020	Education	Information and communication technologies in the teaching of mathematics from the graduates of the degree course — IFS/Aracaju

Source: Prepared by the authors (2025).

The selected studies were analyzed in their entirety following the three phases of Content Analysis: pre-analysis, exploration of the material and treatment of the results. "Content Analysis is a technique that aims at inference through the objective and systematic identification of specific characteristics of messages" (Rodrigues, 2019, p. 22). This analysis process was supported by the Atlas.ti software, a software for the analysis of qualitative data used by researchers from all over the world, considering its ease of use and diversity of tools.

The first phase of Content Analysis, the pre-analysis, "consists of organizing the

material to be analyzed, with the objective of making it operational, systematizing the initial ideas" (Rodrigues, 2019, p. 23). The pre-analysis consists of five stages, namely: skimming reading; constitution of the corpus*;* formulation of objectives; referencing and elaboration of indicators; and preparation of material.

The constitution of the research corpus, although listed by Bardin (1977) as the second stage of the pre-analysis, occurred during the initial process of the systematic review and consists of the theses and dissertations previously presented in Table 2. As Rodrigues emphasizes (2019, p. 22), "as much as certain 'rules' must be respected and the different phases and stages are highlighted, Content Analysis should not be considered and worked on as an exact and rigid model".

It is also worth noting that the Constitution of the corpus met the criteria of the five rules established by the Content Analysis method, namely: exhaustiveness, representativeness, homogeneity, pertinence, and exclusivity (Rodrigues, 2019).

The skim reading stage began with the help of the Atlas.ti software, where the theses and dissertations obtained from BDTD were added in PDF format, the same format in which they were extracted from the database. Next, the introduction and theoretical framework chapters were read, which allowed an initial understanding of the objectives, research question, analysis methods and theoretical basis of the works, in addition to perceiving approximations and distancing, as guided by Silva Junior and Leão (2018).

At this point, Atlas.ti's citation record was particularly useful in allowing the terms, words and expressions, excerpts that made up the indexes to be highlighted, while the software itself was in charge of calculating the indicators.

The preparation of the material took place after the full reading of all the theses and dissertations and consisted in refining the extracted excerpts, which resulted in changes in the descriptions of the codes created in Atlas.ti for better representation and consistencies on the next stage of Content Analysis: the exploration of the material.

In the exploration of the material, the Context Units, understood as relevant parts or excerpts of the document (Rodrigues, 2019) were recorded in Atlas.ti in the Citations area. In the end, a total of 426 citations were extracted from the theses and dissertations, which were grouped in the next phase, according to the degree of affinity.

The Registration Units encompassed the Context Units, so that at the end of the

process there were a total of 20 Registration Units, expressed in Atlas.ti in the area of Codes, which were used for the constitution of the Analysis Categories; before we will deal with the Thematic Axes.

The Thematic Axes consisted, according to Bardin (1977), in the detailed observation of approximations and distancing between the Registration Units. Thus, the Thematic Axes were elaborated: i) curriculum of the Degrees in Mathematics and digital technologies; ii) obstacles faced for the integration of TDIC; iii) conceptions of managers, teachers and students; iv) potential of TDIC in teaching; v) technological, physical and digital resources.

From the Thematic Axes listed, it was possible to elaborate the Analysis Categories, in order to distribute all the Registration Units in a total of 3 Analysis Categories, expressed in Atlas.ti in the Code Groups area. These 3 groups of codes, as well as their abbreviations, can be seen in Table 3.

Table 3 - Groups of codes (Analysis Categories)

Abbreviation	Description
DES	Challenges faced in the integration of digital technologies to the curriculum of bachelor's degrees in mathematics
EST	Proposed strategies for the integration of digital technologies in the curriculum of bachelor's degrees in mathematics
FOR	Mathematics teacher training

Source: Prepared by the authors (2025).

In the following section we present and discuss the results of the research.

RESULTS AND DISCUSSIONS

The final phase of Content Analysis, as Rodrigues (2019) points out, should not be limited to a simple exposition of the data obtained from the excerpts and constitution of the Analysis Categories; On the contrary, it is of great importance to consider the process of treatment of the results in light of the theoretical framework of the research. Thus, the main inferences obtained during the treatment phase of the results are presented next.

Challenges faced for the integration of digital technologies in the curriculum of bachelor´s degrees in mathematics

In this Category of Analysis, many of the challenges listed by the framework were raised, with a more particular focus on the institutions and subjects participating in each research. Issues of infrastructure, insecurities and teacher training, resistance to the integration of TDIC also on the part of students and underuse of digital resources stand out here.

As for the challenges arising from the infrastructure for the integration of TDIC, Souza (2008) points not only to the absence of technological resources, but also to the lack of security provided to the machines, indicating that the professors participating in his research warned of the scrapping or even theft of equipment from the computer labs. In line with this, (Lobato, 2003, p. 76) also points out that if the computers "have any problems, there is no money to fix them".

Lobato (2003), in turn, emphasizes the dichotomy between theory and practice. The author found that the issues regarding the learning/use of digital technologies applied to education are not yet a reality present in the curriculum of the institutions that were researched; On the other hand, it was noted that the institutions continued to contribute to the dichotomy, by separating the contents referring to theory from those referring to practice.

Hermenegildo (2017) points out that the lack of knowledge about GeoGebra and

dynamic geometry software in general, by the undergraduates, implies the need for training during undergraduate disciplines and new looks at the technological environment in integration with education, emphasizing all knowledge, whether professional, curricular, disciplinary or experiential.

In the analysis of the data obtained, Menegais (2015) infers that the training of teachers for the use of digital technologies was not sufficient in the researched institution, with only one mandatory subject linked to the use of TDIC in the PPC analyzed at the time, in addition to one more optional subject.

In relation to teachers' insecurities regarding the use of TDIC, there are points such as lack of interest, opportunity, training and fear. In this Category of Analysis, the "training" factor was in evidence, as Lobato (2003) observes when he emphasizes that, in two of the three institutions considered in his study, most participants considered the integration of TDIC as something important, they did not use them because they did not feel prepared. Only in the third institution considered, participants felt prepared to use digital technologies in teaching.

Regarding the obstacles to the integration of TDIC, Lobato (2003) emphasizes the resistance of educators, pointing out as a possible cause the training that does not include digital technologies in its curriculum; and even as for those that do include, there are sometimes misunderstandings regarding the mastery of a technological resource and its full use in the classroom by the teacher (Colling, 2017), which can intensify the resistance of educators, since "a part of the teachers does not adapt to technologies, rejecting them, due to the conviction that they would be unattainable and incomprehensible by them" (Pacheco, 2020, p. 21).

Table 4 shows the synthesis of the challenges listed by the authors of the analyzed papers.

Table 4 - Summary of the challenges listed

Challenge	Challenge Description
Infrastructure	Absence of adequate equipment, scrapping of machines present in laboratories and lack of funds for repairs.
Theory-practice dichotomy	Separation and lack of interaction between the disciplines that address the theoretical and practical contents around digital technologies.

Insecurities	Challenge derived from factors such as lack of opportunity, interest in training or even fear.
Resistance	Resistance found in educators, managers or students who reject changes in the traditional way of teaching.
Underutilization	Use of digital technologies to reproduce the same teaching practices, hold the student's attention or just to pass the time.

Source: Prepared by the authors (2025).

Proposed strategies for the integration of digital technologies in the curriculum of Bachelor´s Degrees in Mathematics

Regarding integration proposals, Souza (2008) highlights the provision of courses and pedagogical resources for active teachers, in addition to reading articles, aiming at a critical understanding of the advantages and disadvantages of using software; in other words, we have here an integration proposal focused on the perspective of continuing education (Leonel; Angotti, 2017).

Menegais (2015) points to a proposal model based on the realization of projects arguing that in this model the student starts to learn during the process of producing and raising doubts, researching and creating relationships in order to achieve new searches and discoveries, understandings and reconstructions of knowledge, in addition to encouraging students to develop autonomy.

A proposal linked to initial training is the one defended by Araújo (2020), who suggests the inclusion of activities aimed at promoting practical experiences, in the syllabus of training courses, aimed at the insertion of TDIC in the daily life of the school. In this regard, he highlights the Supervised Internships as a field of application of the theories and techniques learned.

Aware of this relationship between Mathematics and TDIC, Souza (2008) points out the importance of thinking about Mathematics as a tool to understand technology and vice versa, a perspective shared by Araújo (2020), who emphasizes the use of resources such as calculators, graphing calculators, and electronic spreadsheets. Pacheco (2020) points out that the technological resources available for learning Mathematics range from simple calculators to complex applications aimed at creating

geometric objects and constructions in 2D or 3D; and it is also possible to integrate mathematical games and the computer, in order to favor learning (Lobato, 2003).

Pacheco (2020), in turn, points out that the use of digital technologies in teaching should be worked on both theoretically and practically and that it should be more present in the curricula of Mathematics Teaching Degree courses, the same as Lobato (2003); active teachers, should pay attention to the offering of courses based on updating and technological training.

Araújo (2020) infers that it is essential to explore mathematical concepts using technological resources, whether through dynamic mathematics software or applications, or using computers or cell phones, such as those that have versions for applications. Thus, he deems it necessary to think about the integration of TDIC for moments beyond the disciplines, so that there is not "a decontextualized teaching, based on old practices with newer resources" (Araújo, 2020, p. 127).

This Analysis Category stands out by suggesting software and digital platforms that aim to support the process of teaching Mathematics, of which the main ones are: Cabri-Géomètre (Souza, 2008; Lobato, 2003; Araújo, 2020); Winplot (Souza, 2008; Hermenegildo, 2017; Pacheco, 2020); Winmat (Pacheco, 2020; Araújo, 2020); SuperLogo (Lobato, 2003; Pacheco, 2020); GeoGebra (Hermenegildo, 2017; Pacheco, 2020; Araújo, 2020); Graphmathica (Hermenegildo, 2017; Araújo, 2020); the Khan Academy platform (Menegais, 2015), among others.

Due to the large number of suggestions, we will now discuss SuperLogo and GeoGebra, as they were the most in-depth in the analyzed works; and Khan Academy, as it stood out in Menegais's (2015) research as a digital platform that aids teaching and due to the possibility of its integration with the other software mentioned above.

SuperLogo is geared towards creating geometric figures. This software stands out for having simple commands, which are used to control the movement of a digital turtle that may or may not leave a trail in the shape of a straight line, thus forming flat or even spatial figures. It is worth noting that this program does not have many problems in its use, as it runs even on older computers, as long as it has the Windows operating system (Pacheco, 2020).

GeoGebra is a multiplatform software that combines geometry, algebra, tables, graphs, statistics and calculus, and stands out as one of the most widely used digital and

disseminated resources for dynamic geometry today (Hermenegildo, 2017). For spatial geometry, one of the great aids provided by GeoGebra consists of the construction of spatial figures and their planning, in addition to the ability to move them freely in the computer interface (Pacheco, 2020).

Khan Academy, founded in 2006, is a non-profit organization whose mission is to offer free and universal education to the world and everywhere. The platform is characterized by its video lessons, lasting approximately 10 minutes, on various content, not only Mathematics. On the platform, the student chooses the subject by themes and studies them at their own learning pace. Thus, Khan Academy provides the teacher with reports that allow him to follow the students' progress in a more individual manner, which is particularly useful in large classes. Menegais (2015) describes that for students, the platform offers a playful experience, similar to a game, which transforms the learning of Mathematics into an adventure where the student acts as the main character.

The Table 5 presents the synthesis of the strategies presented by the authors of the analyzed papers.

Table 5 - Summary of the strategies listed

Strategy	Strategy Description
Initial training	Inclusion of theoretical and practical disciplines in the syllabus of training courses, aiming at the experience with the insertion of TDIC in the school routine.
Continuing education	Courses and pedagogical resources aimed at preparing teachers working on the possibilities, advantages and disadvantages of technological resources.
Projects	Model aimed at the student to produce and raise doubts during the construction and reconstruction of knowledge in an active modality.
Software and digital platforms	Exploration of resources ranging from conventional calculators to graphing calculators, electronic spreadsheets, dynamic geometry software for both 2D and 3D constructions, mobile applications and digital platforms.

Source: Prepared by the authors (2025).

Mathematics Teacher Training

Regarding the role of the Mathematics teacher in teaching with technologies, Hermenegildo (2017) emphasizes the importance of the teacher's action, who is the professional responsible for the pedagogical organization of the classroom and the mediator in the relationship between student, Mathematics and technology. To play such a role, the teacher must be aware that TDIC is not the objective of teaching, but the means.

From an initial training perspective, it is considered important that this training contemplates two senses: "Mathematics as a tool to understand technology, and technology as a tool to understand Mathematics" (Hermenegildo, 2017, p. 51).

From this, it is understood that initial training plays a great role in the process of inclusion of TDIC in teaching (Araújo, 2020), and is also a stimulator for their study in continuing education, a modality to be addressed below.

With regard to continuing education, it is important to think that teacher training does not end with graduation but is a state of learning and permanent adaptation (Hermenegildo, 2017), which is completed in the course of their activities as a teacher (Lobato, 2003).

> However, what is observed in relation to teacher training programs in Computing in Education is a greater concern with teaching "about" the machine than "with" the machine, leaving the idea that it is enough to have state-of-the-art equipment and good educational software to solve all the problems of education (Lobato, 2003, p. 93).

In this sense, it is essential that the continuing education of teachers considers technological advances, as well as the school space, which is the place where these professionals work, and the experiences arising from their practices and experiences (Menegais, 2015).

FINAL CONSIDERATIONS

Based on the guiding question, "how have the curriculum of Mathematics Teaching Degree courses incorporated discussions and practices on the use of digital technologies?", the present research aimed to analyze these discussions and practices through a systematic review of the literature.

The exploration of the data obtained in the theses and dissertations, in light of Bardin's Content Analysis (1977), made it possible to develop three Categories of Analysis, which allowed us to visualize the challenges and obstacles, strategies and possibilities, and the scenario of digital technologies in the training of teachers who teach Mathematics

From the Analysis Category "Challenges faced for the integration of digital technologies in the curriculum of Mathematics Degrees", it was noted that, in some of the institutions considered in the analyzed works, some teacher trainers and universities have paid more attention to the integration of TDIC in their curriculum and sought to provide training for it, but there is still resistance on the part of managers, teachers and students, or even ineffective attempts that end up falling into instrumental use of technological resources, an underuse.

In the Analysis Category "Proposed strategies for the integration of digital technologies in the curriculum of Mathematics Degrees", much was commented on the use of computers and software for the teaching of Mathematics, emphasizing the overcoming of problems with infrastructure and access to the internet; however, although little commented, the use of applications can be suggested as an alternative to this barrier, since some programs such as GeoGebra have a smartphone version.

The Analysis Category "Mathematics teacher training" dealt with both the role of the teaching professional, the mediator of the relationship between student, mathematics and technologies, and the intimate relationship between initial and continuing education, which should be allied in a perspective of continuous training in which mathematics is a tool to understand technologies and vice versa.

Through this study, it was found that the incorporation of TDIC in the curriculum of Mathematics Teaching Degree courses is essential for the initial training of future teachers. However, it was evidenced that neglecting the potential of digital technologies for teaching in initial training can cause resistance and future difficulties on the part of

teachers. Furthermore, even if there is an initial training with the incorporation of TDIC, it is essential to continue the training process through a continuum that familiarizes teachers with the constant advances and technological innovations. Thus, it is emphasized that the process of appropriation of the use of technologies in education by future teachers, in line with Shulman's (1986, 1987) propositions about the knowledge base for teaching, lacks a solid articulation between initial and continuing education of teachers, so that both are aligned with the perspective of a digital culture that promotes the development of reflective postures in the face of TDIC and its implications in the daily school life.

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REFERENCES

ARAÚJO, Wellington Alves de. **Tecnologias da informação e comunicação no ensino de matemática a partir dos egressos do curso licenciatura — IFS/Aracaju**. Tese (Doutorado em Educação) — Universidade Federal de Sergipe. São Cristóvão, 158 p. 2020. Disponível em: https://ri.ufs.br/jspui/handle/riufs/14919. Acesso em: 05 jun. 2025.

BARDIN, Laurence. **Análise de conteúdo**. Lisboa: Edições 70, 1977.

BRAGAGNOLLO, Karina Fonseca; OENNING, Weslaine Granella; SOUTO, Daise Lago Pereira. Tecnologias digitais na licenciatura em matemática: outro zoom. **Perspectivas da Educação Matemática - INMA/UFMS**, v. 13, n. 33, 2020. Disponível em: https://periodicos.ufms.br/index.php/pedmat/article/view/10573. Acesso em: 05 jun. 2025.

BRASIL, Lei de Diretrizes. **Parecer CNE/CP 009/2001 - Diretrizes Curriculares Nacionais para a Formação de Professores da Educação Básica, em nível superior, curso de licenciatura, de graduação plena**, v. 8, n. 05, 2001. Disponível em: http://portal.mec.gov.br/cne/arquivos/pdf/009.pdf .Acesso em: 12 maio 2025.

BRIZOLA, Jairo; FANTIN, Nádia. Revisão da literatura e revisão sistemática da literatura.

RELVA, Juara/MT/Brasil, v. 3, n. 2, p. 23-39, jul./dez. 2016. Disponível em: https://periodicos.unemat.br/index.php/relva/article/view/1738. Acesso em: 21 br. 2025.

CAMPOS, Alessandra Freire Magalhães de; CAETANO, Luís Miguel Dias; LAUS-GOMES, Victor. Revisão sistemática de literatura em educação: Características, estrutura e possibilidades às pesquisas qualitativas. **Revista Linguagem, Educação e Sociedade - LES**, v.27, n.54, p. 139-169, 2023, eISSN: 2526-8449. Disponível em: https://doi.org/10.26694/rles.v27i54.2702. Acesso em: 21 mar. 2025.

COLLING, Juliane. **Perspectivas de articulação dos conhecimentos pedagógicos, tecnológicos e do conteúdo na formação inicial de professores de matemática**. Dissertação (Mestrado em Educação). Universidade Federal da Fronteira Sul. Chapecó, 165 p. 2017. Disponível em: https://rd.uffs.edu.br/handle/prefix/1668. Acesso em: 10 maio 2025.

GALVÃO, Maria Cristiane Barbosa; RICARTE, Ivan Luiz Marques. Revisão sistemática da literatura: conceituação, produção e publicação. **LOGEION: Filosofia da informação,** Rio de Janeiro, v. 6 n. 1, p. 57-73, set. 2019/fev. 2020. Disponível em: https://revista.ibict.br/fiinf/article/view/4835. Acesso em: 24 maio. 2025.

HERMENEGILDO, Késia de Mélo. **Os saberes da formação inicial de professores para a integração da investigação em matemática com recursos da geometria dinâmica**. Dissertação (Mestrado em Educação Matemática) — Universidade Estadual da Paraíba. Campina Grande, 139 p. 2017. Disponível em: https://pos-graduacao.uepb.edu.br/ppgecm/download/disserta%C3%A7%C3%B5es/mestrado_profissional/2017/KESIA-DE-MELO-HERMENEGILDO-DISSERTACAO_2.pdf. Acesso em: 10 jun. 2025.

KENSKI, Vani Moreira. **Tecnologias de ensino presencial e a distância**. São Paulo: Papirus, 2003. Disponível em:https://biblioteca.sophia.com.br/terminal/7615/Acervo/Detalhe/2437?returnUrl=/terminal/7615/Home/Index&guid=1573689606014. Acesso em: 20 maio 2025.

LEONEL, André Ary; ANGOTTI, José André Peres. Formação continuada para físicos educadores: potencializando a integração das TDIC no processo de ensino-aprendizagem de física. **Enseñanza de las Ciencias**, p. 2713-2718, 2017. Disponível em: https://core.ac.uk/download/pdf/160038322.pdf. Acesso em: 12 abr. 2025.

LOBATO, Lúcia Helena dos Santos. **Informática na educação**: a matemática e seus professores a caminho de uma nova realidade escolar. Dissertação (Mestrado em Engenharia de Produção) — Universidade Federal de Santa Catarina. Florianópolis, 163 p. 2003. Disponível em: https://core.ac.uk/download/pdf/30382153.pdf .Acesso em: 10 abr. 2025.

MENEGAIS, Denice Aparecida Fontana Nisxota. **A formação continuada de professores de matemática**: uma inserção tecnológica da plataforma Khan Academy na prática

docente. Tese (Doutorado em Informática na Educação) — Universidade Federal do Rio Grande do Sul. Porto Alegre, 201 p. 2015. Disponível em:https://lume.ufrgs.br/handle/10183/122036. Acesso em: 10 abr. 2025.

PACHECO, Edevaldo Gomes. **Utilização da tecnologia na formação de professores de matemática da região norte do Brasil**. Dissertação (Mestrado em Matemática) — Universidade Federal do Tocantins. Palmas, 128 p. 2020. Disponível em: https://repositorio.uft.edu.br/handle/11612/2795. Acesso em: 10 mar. 2025.

RODRIGUES, Márcio Urel. **Análise de conteúdo em pesquisas qualitativas na área da educação matemática**. Curitiba: CRV, 2019.

SCHERER, Suely; BRITO, Gláucia da Silva. Integração de tecnologias digitais ao currículo: diálogos sobre desafios e dificuldades. **Educar em Revista**, Curitiba, v. 36, 2020. Disponível em: https://www.scielo.br/j/er/a/FCR5M56M6Chgp4xknpPdKmx/. Acesso em: 19 maio 2025.

SHULMAN, Lee S. Those who understand: knowledge growth in teaching. **Educational Research**,15(2), p. 4-14, feb, 1986. Acesso em: 30 mar. 2025. Disponível em: http://links.jstor.org/sici?sici=0013-189X%28198602%2915%3A2%3C4%3ATWUKGI%3E2.0.CO%3B2-X. Acesso em: 23 maio 2025.

SHULMAN, Lee S. Knowledge and teaching: foundations of the new reform. **Harvard Educational Review**, *57*(1), 1-23, 1987. Acesso em: 30 mar. 2025. DOI: https://doi.org/10.17763/haer.57.1.j463w79r56455411

SILVA JUNIOR, Luiz Alberto; LEÃO, Marcelo Brito Carneiro. O software Atlas.ti como recurso para a análise de conteúdo: analisando a robótica no ensino de ciências em teses brasileiras. **Ciênc. Educ.**, Bauru, v. 24, n. 3, p. 715-728, 2018. Disponível em: https://www.scielo.br/j/ciedu/a/yBwC9L74v4vD3s4PwVXggsk/abstract/?lang=pt. Acesso em: 20 maio 2025.

SOUZA, Jediane Teixeira de. **As tecnologias de informação e comunicação em cursos de licenciaturas em matemática.** Dissertação (Mestrado em Ensino de Matemática) — Pontifícia Universidade Católica de São Paulo. São Paulo, 121 p., 2008. Disponível em: https://tede2.pucsp.br/handle/handle/11313.Acesso em: 10 abr. 2025.