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Training of teachers who teach Mathematics with DICT in the Elementary School: a systematic review of the SBEM publications

Abstract: This bibliographic survey identifies teachers training models that address the teachers training for assignments in mathematics in the Elementary School with DICT. We use, as a theoretical foundation, the training models of José Contreras, and the documentary research methodology of the chronicle type. We have investigated a total of ten articles which were published between 2013 and 2022, in the SBEM journals, and in articles from the ENEM annals. The analysis showed the implicit predominance of the reflective training model for teachers. Thus, we point out the need for research that theoretically explains the training models being used and that addresses the use of DICT from the perspective of the critical intellectual model of mathematics teachers training.

Keywords: Teachers Training. Training Models. DICT. Teaching of Mathematics.

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Article

Formación de docentes que enseña Matemáticas con TDIC en la Educación Primaria: una revisión sistemática de las publicaciones de la SBEM

Resumen: El levantamiento bibliográfico identifica modelos de formación docente que abordan la formación docente en Matemáticas en la Educación Primaria con TDIC. Utilizamos, como fundamento teórico, los modelos de formación de José Contreras; y la metodología de investigación documental, tipo crónica. Investigamos las producciones publicadas, entre 2013 y 2022, en revistas de la SBEM y en artículos de los anales del ENEM, en los que encontramos un total de diez artículos. El análisis mostró el predominio implícito del modelo de formación docente reflexiva. Así, señalamos la necesidad de investigaciones que expliquen teóricamente los modelos de formación utilizados y aborden el uso de las TDIC desde la perspectiva del modelo intelectual crítico de la formación del profesorado de Matemáticas.

Palabras clave: Formación Docente. Modelos Formativos. TDIC. Enseñanza de Matemáticas.

Formação de professores que ensinam Matemática com TDIC nos Anos Iniciais: uma revisão sistemática das publicações da SBEM

Resumo: O levantamento bibliográfico identifica os modelos formativos de professores que abordam a formação de ensino em Matemática nos Anos Iniciais com TDIC. Utilizamos, como fundamentação teórica, os modelos formativos de José Contreras; e a metodologia de pesquisa documental, tipo crônica. Investigamos as produções publicadas, entre 2013 a 2022, nos periódicos da SBEM e nos artigos dos anais do ENEM, em que encontramos um total de dez artigos. A análise mostrou a predominância de forma implícita do modelo formativo de professores reflexivo. Assim, apontamos como demanda a necessidade de pesquisas que explicitem teoricamente os modelos formativos utilizados e abordem o uso das TDIC numa perspectiva do modelo intelectual crítico de formação de professores de Matemática.

Palavras-chave: Formação de Professores. Modelos Formativos. TDIC. Ensino de Matemática.

1 Introduction

Contemporary society is marked by the hegemony of digital culture, in which Digital Information and Communication Technologies — DICT change both the way we live and how we relate to others in society (Kenski, 2012). Not even childhood escapes the digital domain, as the manual toys of old give way to the digital information and communication technologies (DICT) and children become "digital natives" (Prensky, 2001). But, if it is the forms of life that determine consciousness (Marx and Engels, 2007), then DICT play a determining role in our forms of sociability (Kenski, 2012).

In this context, as Moran (2019) highlights, facing the challenges of contemporary education implies not only adapting to the demands of digital culture, but also training students and teachers for the conscious and critical use of DICT. In studies by Santos and Sá (2021) as well as Brito and Costa (2020), the authors consider that teacher training in the use of technologies enables the inclusion of technological resources in pedagogical practice. To this end, they emphasize that training must take place from a critical reflective perspective, that is, it goes beyond the mere use of resources by encompassing the understanding of the implications of this use in a context of digital culture.

In a critical approach to the use of Digital Information and Communication Technologies (DICT), Belloni (1998) and Pesce (2013) propose to place teaching practice in an authorial perspective. They defend a vision that transcends the mere technical use of DICT, by emphasizing the importance of a critical and authentic reflective approach to the educational process, since, from that perspective, the teacher will have theoretical and practical conditions to break with passive practices of using DICT, which are limited to the technical use of resources (Kirchner and Bruyckere, 2017).

In this sense, that change of approach in educational practice proves to be crucial in school education, for the use of digital technologies by the subject, especially those in the process of development and learning, must be guided, systematized and linked to the *basic knowledge*, considered universal for children and adolescents, as recommended by the National Common Curricular Base (Brasil, 2017). Therefore, it is unfeasible to consider the use of DICT disconnected from the school educational process, given that digital culture has also been established within this premises. Kenski (2018, p. 139) describes digital culture as

> a new, current, emerging and temporal term. The expression integrates different perspectives linked to innovations and advances in knowledge, and their incorporation, provided by the use of digital technologies and network connections to carry out new types of interaction, communication, sharing and action in society.

We cannot, therefore, confuse *Digital Culture* with *Digital Literacy*, as they are different concepts. While the first is characterized by the human connection with digital technology, in which the form of interaction, communication, sharing of information is configured in a new culture (Kenski, 2018), the second is part of *Digital Culture*. For Buzato (2006, p. 9),

> Digital literacies (DLs) are sets of literacies (social practices) that support themselves, intertwine and, mutually and continuously, appropriate each other through digital devices for specific purposes, both in geographically and temporally limited sociocultural contexts, and in those constructed by electronically mediated interaction.

From the perspective of digital literacy (DL), training teaching models determine the

conduct of the process but for it to occur in teaching practice, it must adapt to the contemporary world, considering not only the individualities of students, but also their connection with the society in general, in order to establish a link with critical-transformative knowledge (Contreras, 2012).

Teacher training, in that perspective, directly influences practice and teaching. Based on those reflections, we propose to carry out a survey of scientific productions on the use of DICT in the educational context, through the training processes of teachers who teach Mathematics in the Elementary School. Combining our concerns with the teaching of Mathematics at such stage, we have proposed the following research question: *What are the training models that shape the researches about the training of those teachers who teach Mathematics in the Elementary School using DICT?*

To answer the research question, we have used, as a basis, the classification of training models presented by Contreras (2012). In order to do that we have carried out a literature review in the journals of the Brazilian Society of Mathematics Education (SBEM), in addition to the last four annals of the National Meeting of Mathematics Education, linked to the SBEM, within the period from 2013 to 2022. In addition, we have also carried out a description about the research methodology, theoretical framework, aim and results of the articles collected, by using the chronicle documentary research methodology.

Thus, in this article, in the following sections, we present the theoretical framework that describes the teacher training models proposed by Contreras (2012), which have served as a basis for classifying the training models presented in each of the ten papers. In the second section, we discuss the methodological approach and, following, the presentation of the results and discussions. Finally, in the final considerations, we briefly argue why we consider the results obtained to be disturbing and the need for a more incisive assessment of the training of teachers for the use of DICT.

2 Theoretical Framework

In the present study, we are making use of Contreras (2012) in order to analyze training models, namely: the teacher as a technical, reflective, critical and transformative intellectual. The technical specialist or technical professional is thought of from the perspective of technical rationality, which focuses on the conception that pedagogical knowledge can be transmitted to teachers through predefined techniques and procedures, with the teachers simply being responsible for applying them in their teaching practice. Contreras (2012) criticizes such model, as it limits the teacher's practice to the rationalization of paper, when

> the consideration of professional practice as the application of procedures and technical means to achieve certain ends understands the applied science as the formulation of technological rules, according to which those action procedures that give rise to certain desired results are established (Contreras, 2012, p. 91).

By limiting the practice to the compliance with established norms and rules, pre-established by other people or legislation, not taking into account the adversities of everyday life, that model is not capable of meeting all the demands of an educational process, taking into account the reality of each institution.

A possibility that contrasts with the technical model is the reflective professional model, cited by Contreras (2012). That model refers to the ideas of Schön (1992) when considering that professional practice involves making complex decisions, that is, it involves solving

problems which were not foreseen, and which are not solved by technical knowledge. Schön (1992) emphasizes that professionals, as well as teachers, need to develop skills such as *reflection in the action* and *reflection on the action*, to deal with challenging and unpredictable situations in the classroom context.

Contreras (2012), however, criticizes that model, since he understands that such a professional can solve the problems experienced in the classroom, but does not go beyond the school walls. The professional reflects in the action and on his or her action and tries to propose strategies to improve that specific problem but does not problematize or intervene in relation to social issues, such as social inequality.

An alternative model to the reflective one is the critical intellectual teacher training model. Contreras (2012), when defining that model characteristics, bases himself on the proposals of Wilfred Carr, Stephen Kemmis and Henry Giroux. Those authors understand that the critical intellectual teacher training model questions what is established, and "intellectualizes" its practice in a progressive way. In such model, there is an emphasis on the need for professionals to reflect and problematize the social, cultural, and political influences that shape the educational context and teaching practice.

For a better understanding, Queirós (2012) presents a division of the critical intellectual model into reflective critical intellectual and transformative critical intellectual. In the critical reflective intellectual model, the professional seeks to identify and to reflect on the contradictions, injustices and inequalities present in the educational system, that is, there is encouragement to question the established norms.

The transformative critical intellectual model proposes instead a broader training, which includes not only a critical reflection of the social and political reality in which education is inserted, but also the employment of practical actions of a transformative nature. It is understood as a professional who is committed to the intellectual and the social transformation, in relation to the educational process, without neglecting the political nature inherent to the school, teachers and the course syllabus.

Such a transformative critical professional reflects and acts critically in relation to the social, political, cultural, and economic aspects besides using radical social theory as a basis for engaging in public spaces and promoting individual and collective freedom (Giroux, 1997). That may involve participation in councils, committees, working groups and other instances of dialogue and negotiation, with the aim of influencing public policies in a more inclusive, democratic way as well as being aligned with the principles of social justice and equity.

Such reflections and actions can be used to approach DICTs in teachers' training and are corroborated by Pesce, Bueno and Peixoto (Pesce, 2013; Bueno and Peixoto, 2022), who consider that digital literacy, from the perspective of the critical intellectual model, provides awareness about the social, political and cultural dimensions of digital information and communication technologies. Students would be encouraged to question the influence of DICT in different contexts and to reflect on the ethical implications, privacy, inequalities and power related to the use of digital communication and information technologies (Bueno and Peixoto, 2022). A practical example of the use of the critical intellectual model in teachers' training with DICT:

> [...] the training process was supported by a critical-reflexive perspective, contributing to the rethinking of the teaching practice regarding the use of DICT, with an emphasis on the ODA of the Currículo+ Platform. In that opportunity, we can observe that the

> course under analysis has contributed to the Freirean empowerment of teachers, situated in an authorial perspective (Nogueira, 2017, p. 12).

In this way, the practices of using DICT in the critical intellectual model aim to go beyond the simple technical use of technologies, but to promote, in addition, a reflective, critical and transformative approach to the training processes. In this sense, the present study supports this vision of a transformative critical intellectual in the approach to DICT, during the educational process both in basic education and in teacher training as well. However, as our research is bibliographic in nature, we will be using the definitions of the different training models presented in the following section in order to analyze the studies that address the use of DICT in teachers' training.

3 Methodological Path

In order to answer the question being addressed, the preparation of this study has been carried out through documentary research. The data collection has been done in the journals published by the Brazilian Society of Mathematics Education (SBEM), from 2013 to 2022, and in the papers published by the annals of the National Meeting of Mathematics Education (ENEM), also linked to the SBEM, from the editions of 2013, 2016, 2019 and 2022. Those four editions meet the ten-year period established for this research, as the ENEM publications take place every three years.

Documentary research allows the researcher to understand the object of study and, based on what has already been produced, to bring about its delimitations by directing the focus towards the established objectives. Therefore, that type of research might be either synthetic or chronicle. The chronicle type is our choice in the present study since we describe what has been brought in by each one of the papers which have been analyzed, in the sense of "which question has been answered, which methodology has been employed, what have been the results obtained and so on" (Rosa, 2015, p. 56).

Among the periodicals which have been published by the SBEM there are: *Educação Matemática em Revista* (EMR), *Revista Internacional de Pesquisa em Educação Matemática* (RIPEM), *Educação Matemática em Revista RS* (EMR/RS), *Temas e Debates* (TeB), *Revista Catarinense de Educação Matemática* (RECEM), and the *Revista Cearense de Educação Matemática* (RCeEM).

In order to achieve more satisfactory results in data collection, we have created fourth searches in each of the SBEM journals, which are classified by their numerical order of searching, such as first, second, third, fourth and fifth search. In each search, we are presenting only the quantity of articles which have been found: in the first search, by using the keywords "teacher training and digital technologies", we have obtained 5 EMR articles, 4 EMR/RS articles and 5 RCeEM articles; the second search was "digital technologies and mathematics" and we have found 20 EMR articles, 3 RIPEM articles, 17 EMR/RS articles and 5 RCeEM articles; the third one, "digital technologies and Elementary School", has found 8 EMR articles, 2 EMR/RS articles and 5 RCeEM articles. In the fourth and final search, "digital technologies and Elementary School", there have been found 23 articles from EMR, 5 from EMR/RS, and 3 RCeEM articles.

To connect or exclude themes, we use the search tool Boolean with the operators "and, or, not" and "to", in the field of searching. Thus, we have established the exclusion criteria, as only the framework training for teachers who teach mathematics in the Elementary School, for the use of DICT have been used, which resulted in a total of ten articles.

Table 1 succinctly presents the results of collected articles, with the title of the productions, the year of publication, the periodical and/or year in which the ENEM event took place. Each article was classified by lowercase letter and numbering, according to the number of productions, which made up the literature review for this article.

Table 1: Articles of the ENEM and journals of the SBEM

ID	Artigo
[a1]	LEANDRO, Everaldo Gomes; LIMA, Rodrigo Ferreira; LIMA, Tarcísio de Souza; NASCIMENTO, Lauriza Quina Barreto. Luz, câmera, ação... quando professores que ensinam Matemática nos Anos Iniciais criam filmes de curta-metragem [Lights, camera, action... when teachers who teach Mathematics in the Elementary School create short films]. *Educação Matemática em Revista*, v. 22, n. 53, p. 99-108, jan./mar. 2017.
[a2]	PAULA, Jaqueline Borges de; PALMA, Rute Cristina Domingo de; ROOS, Deise; LIMA Daniela Maria Almeida. Aprender e Ensinar Geometria Remotamente: Enfrentamentos didáticos de professores dos Anos Iniciais em tempo de pandemia [Learning and teaching Geometry remotely: teaching challenges of Elementary School teachers in times of pandemic]. *Revista Internacional de Pesquisa em Educação Matemática,* v. 12, n. 3, p. 55-72, 2022.
[a3]	SILVA, Eber Gustavo; MELO, Regina Celi. M; MORAIS, Maria das Dores. O uso de tecnologias digitais da informação e comunicação fomentando o letramento matemático na formação de professores de Matemática dos Anos Iniciais [The use of digital information and communication technologies promoting mathematical literacy in the training of Mathematics teachers in the Elementary School]. *Revista Internacional de Pesquisa em Educação Matemática*, v. 13, n. 1, p. 1-20, 2023.
[a4]	NOGUEIRA, Cleia Alves. Formação de professores para utilização do software KTURTLE no Ensino da Matemática [Training teachers to use the kturtle software in teaching Mathematics]. In: *Anais XI do Encontro Nacional de Educação Matemática*. Curitiba, 2013, p. 1-10.
[a5]	ORLOVSKI, Nelem.; KALINKE, Marco Aurélio; MOCROSKY, Luciane Ferreira. A formação tecnológica de professores que ensinam matemática nos anos iniciais: limites e possibilidades [The technological training of teachers who teach Mathematics in the Elementary School: limits and possibilities]. In: *Anais XI do Encontro Nacional de Educação Matemática*. Curitiba, 2013, p. 1-10.
[a6]	VIEIRA, Edith Resende Vieira; DA COSTA, Nielce Meneguelo Lobo. Ensino de Geometria com tecnologia digital: experiências possíveis em um processo formativo [Teaching Geometry with digital technology: possible experiences in a training process]. In: *Anais do XII Encontro Nacional de Educação Matemática*. São Paulo, 2016, p. 1-10.
[a7]	SOUZA, Andréia Rabello de; GUÉRIOS, Ettiene Cordeiro. O letramento digital no ensino da matemática sob a perspectiva de complexidade [Digital literacy in teaching Mathematics from the perspective of complexity]. In: *Anais do XIII Encontro Nacional de Educação Matemática*. Cuiabá, 2019, p. 1-15.
[a8]	SANTANA, Muller Rodrigo de Moura. O TPACK e a avaliação de tecnologias digitais no contexto da formação docente. In: *Anais do XIV Encontro Nacional de Educação Matemática*. Brasília, 2022, p. 1-10.
[a9]	BLAUTH, Ivonete. Fatima; SCHERER, Suely; CORRÊA, Barbara. Drielle Roncoletta. Formação continuada de professores que ensinam matemática nos anos iniciais e o uso do aplicativo base blocks. [Continuing training of teachers who teach Mathematics in the Elementary School and the use of the Base Blocks application] In: *Anais do XIII Encontro Nacional de Educação Matemática*. Cuiabá, 2019, p. 1-15.
[a10]	FREITAS, Claudio Lopes; MANFREDO, Elizabeth Cardoso Gerhardt. Formação docente para o uso do software GeoGebra no ensino de matemática nos anos iniciais: uma revisão bibliográfica [Teacher training for the use of GeoGebra software in teaching Mathematics in the Elementary School: a bibliographic review]. In: *Anais do XIV Encontro Nacional de Educação Matemática*. Brasília, 2022, p. 1-11.

Source: Own elaboration

Finally, following the procedure of documentary research of the chronicle type, we describe the methodologies, objectives, main results and conclusions of each of the studies. We then analyze the articles according to the theoretical framework proposed in this study, which is the teacher training standards classified according to Contreras (2012), that is, technical, reflective, and critical intellectual (critical reflective and transformative critical intellectual).

4 Results

In this section, we describe the research using the research methodology of the type of chronical documentary. Based on the articles found in the periodicals published by the Brazilian Society of Mathematics Education and in the annals of ENEM as shown in Table 1, in a total of ten documents. This section has been categorized into two parts: the analysis of articles found in the SBEM and in the ENEM periodicals respectively, with their descriptions and analyzes.

4.1 Articles: Journals of the SBEM

The article *Luz, câmera, ação... quando professores que ensinam Matemática nos Anos Iniciais criam filmes de curta-metragem* [Lights, camera, action... when teachers who teach Mathematics in the Elementary School create short films] has aimed to "report this experience and analyze the pedagogical, mathematical content and technological knowledge […] mobilized when teachers of the early years have the opportunity to create scripts and short films, designed for teaching and learning Mathematics" (Leandro *et al*., 2017, p. 100). Their research methodology has not been explained. However, they used the pedagogical knowledge mobilized through Tardif's theory (2014), which discusses the role of practical training in the development of professional knowledge.

The training reported by the authors of the article was based on the creation of short film scripts designed to teach mathematics content, such as numbers and measurements, in the Elementary School. To make and produce these short films, have been used a computer, a cell phone, a Cam Scanner and the Format Factory software, the YouTube and the Google platform, which were considered by the author to be digital technologies that help as a mediating resource in the preparation of short films.

The article *Aprender e ensinar Geometria remotamente: enfrentamentos didáticos de professores dos Anos Iniciais em tempo de pandemia* [Learning and teaching Geometry remotely: teaching challenges of Elementary School teachers in times of pandemic] (Paula *et al.,* 2022) was published in the RIPEM and addresses a continued training for teachers, who teach mathematics in the Elementary School, by means of the emergency remote teaching. That paper has aimed to:

> Analyze and to reflect on the process of learning and teaching Geometry [*sic*] in the scenario specifically outlined by Remote Teaching [*sic*], seeking to observe the highlighted confrontations and to understand how educators and students (re)acted in the process of appropriating this "new" educational environment and scenario (Paula *et al.,* 2022, p. 55).

In that sense, the authors relied on a research using qualitative investigative methodology, with an interpretative nature, whose analysis was constituted through oral narratives (O.N.) and written narratives (Reports of Experiences — R.E.) produced during the training meetings and the interview narrative (I.N.). It has as a theoretical basis the discussions about the teaching of geometry and the emergency remote teaching.

Given the results of the research, the authors considered that the school and the students

families access to digital technologies were in a limited extent, that is, they both had to deal with the scarcity of digital technologies to conduct the emergency remote teaching. Even with those difficulties, the continued training has contributed to developing mathematical and technological knowledge, through the use of DICT, which have provided conditions for promoting mathematics classes, through remote teaching.

The article *O uso de tecnologias digitais da informação e comunicação fomentando o letramento matemático na formação de professores de Matemática dos Anos Iniciais* [The use of digital information and communication technologies promoting mathematical literacy in the training of Mathematics teachers in the Elementary School] (Gomes, André e Morais, 2023) addresses the continued training, in the remote model, for teachers who teach mathematics in the early years initials, whose objective was

> To analyze the strategies mobilized by mediators in the training process with municipal multipliers in the early years of the state of Pernambuco through the use of digital information and communication technologies (DICT), promoting mathematical literacy among peers in remote times (Gomes, André e Morais, 2023, p. 1).

The qualitative approach study had as a research instrument for data production the analysis of recordings, a non-participant observation and it was anchored in the French discourse analysis methodology, in the following categories: the use of technologies as a technique; the use of DICT in the digital literacy process; and learning scenarios, whose theoretical basis were the discussions about mathematical literacy, digital culture, liquid modernity and teachers training.

As a result of the data analysis, the authors have created two categories in relation to digital information and communication technology — DICT: one is focused on learning the technique for the formative process of mathematical literacy and the other on the use of DICT to promote literacy mathematical. In this second category, they understood that DICT are treated as tools to provide knowledge of mathematical literacy, that is, they end up reproducing what would happen in the traditional way (blackboard and chalk), through technological resources, such as computers and overhead projectors, among others.

4.2 Articles: Annals of the ENEM

The research by Nogueira (2013), *Formação de professores para utilização do software kturtle no ensino da Matemática* [Training teachers to use the kturtle software in teaching Mathematics], presents a report on experiences of developing mathematics activities, with the free software KTurtle, in the continued training of teachers of the initial and Midle School, offered by the Educational Technology Center (ETC of Ceilândia, DF). That article does not make clear the methodology used; it only describes how the workshops were carried out with the KTurtle software, promoted through a training for teachers of the initial and Midle School.

The theoretical framework adopted is related to the teaching of mathematics, more specifically, geometry, considered essential for the individual's education. D'Ambrosio (1999) proposes a broader perspective for teaching mathematics, which considers culture, society and different forms of knowledge and makes a connection between the learning of that knowledge and digital technologies, by demonstrating the contributions that DICT can bring to that learning process.

The purpose of that training was to use computer laboratories, having concluded that teachers have changed their practice, that is, they left the traditional practice and added

technologies, in addition to showing students that technological resources go beyond games, as a form of amusement, since they can contribute to the knowledge of mathematics.

The text *A formação tecnológica de professores que ensinam Matemática nos Anos Iniciais: limites e possibilidades* [The technological training of teachers who teach Mathematics in the Elementary School: limits and possibilities], belongs to Orlovski, Kalinke e Mocrosky (2013) and presents as its objective "to highlight how teacher training has been welcomed and treated in public policies" (p. 2). There is no description of the research methodology used, however, it presents a synthesis of how the *One Computer per Student* training has been developed and brought critical considerations, in accordance with the theoretical framework and how the public policies treat teachers training.

From that perspective, the authors bring as a reference studies that deal with permanent teacher training and technologies; digital inclusion and the role of the teacher in the process; and the concept of cyberculture, which portrays a new connection between knowledge and education through the speed of information and knowledge.

In that sense, the authors select the *One Computer per Student Program* (PROUCA) and the *Conection School* program, which are part of the continuing education proposal, through a teachers' training experience, who teach mathematics in the early years, at the county public schools from Curitiba. Those programs are considered proposals for digital inclusion, because they have enabled new trends in the use of technologies in schools.

In relation to the previous considerations, the authors emphasize that it is necessary to open space for discussions about the understanding of DICT in schools and what contributions they can provide. They criticize the programs, when they indicate through evaluation and analysis that the use of those computers is configured from a content perspective in schools, since the program was proposed from a digital inclusion perspective, but this does not happen in teaching practice.

The article by Vieira e Da Costa (2016), *Ensino de Geometria com tecnologia digital: experiências possíveis em um processo formative* [Teaching Geometry with digital technology: possible experiences in a training process], presents reflections through qualitative research, with the characteristic of investigation-action research methodology, on continued training, with three teachers of the Elementary School, within the school space. The main theme is the teaching of geometry with the use of digital technologies, whose theoretical framework adopted on teacher training was based on Leontiev (2004), who defends the theory that the subject learns when he enters into activity, that is, the skills of human beings are acquired through activity and not inherited.

The proposed activities have focused on plane geometry, using the softwares Compass and Ruler, Sketchup and Construfig3D. As a result, it was found that the proposal for training in activity for teaching geometry, with the use of digital technologies, favored the process of appropriating the geometry content, in addition to favoring the technological knowledge of applications.

The production by Souza e Guérios (2019), *O letramento digital no ensino da Matemática sob a perspectiva de complexidade* [Digital literacy in teaching Mathematics from the perspective of complexity], aimed to investigate "what are the consequences of digital literacy, in a context of pedagogical intervention aimed at teachers who teach mathematics" (p. 1). The authors mentioned that the methodology is qualitative, which was applied to pedagogical intervention research with teachers, who teach mathematics in early childhood education and in the Elementary School, through the use of technological resources, such as the

iPad, computer and cell phone connected to an internet network, that is, resources that enable digital production; data analysis was based on the cognitive principles of Morin's Thinking Complex (2011).

From that perspective, the theoretical framework has been aimed at teachers training in connection with to the practice in the practice (Candau, 1995) and at digital literacy based on studies by Silva (2012). After the pedagogical workshop, a questionnaire and interview have been applied, in which the collected data was discussed. The authors brought as the results the reflection of digital literacy in the pedagogical practice of teachers participating in the research, pointing out the use of iPad and computers as a way of using games, such as Minecraft, to carry out activities, which add to the learning of mathematics content and enable digital literacy.

The research by Blauth, Scherer and Corrêa (2019), *Formação continuada de professores que ensinam Matemática nos Anos Iniciais e o uso do aplicativo Base Blocks* [Continuing training of teachers who teach Mathematics in the Elementary School and the use of the Base Blocks application], is the result of one of the continuing training actions developed with teachers at this stage of elementary education in a public county school in the city of Campo Grande (MS).

That training aimed to "integrate digital technologies into the school syllabus of the early years" (Blauth, Scherer and Corrêa, 2019, p. 1). The analysis methodology was configured in narrative and the actions for teachers training for the teaching of mathematics and the use of technologies, and it was based on the framework that addresses teachers' knowledge, in both digital literacy and in digital technologies, with an approach to the integration of digital technologies.

In that way, the authors have collected data through observation of planning meetings, meetings, observations in classes and workshops, in which teachers produced activities related to the content of numbers and operations, using the Base Blocks app and the digital whiteboard. They point out that continued in-service training can contribute to the integration of digital technologies in the teaching of mathematics, as well as in other subjects.

The article by Freitas and Manfredo (2022), entitled *Formação docente para o uso do software GeoGebra no ensino de Matemática nos Anos Iniciais: uma revisão bibliográfica* [Teacher training for the use of GeoGebra software in teaching Mathematics in the Elementary School: a bibliographic review], results from the development of a research-training. As a part of the paper, they carried out a bibliographical review, through documentary research and a narrative description of the results, whose main objective was "to highlight the contributions of continuing education classes, on the use of GeoGebra software, in the development of geometric activities, for the digital and mathematical literacy of teachers who teach mathematics in elementary I" (p. 1).

The theoretical framework adopted was the technological and pedagogical knowledge of the contents (TPACK) linked to the study of mathematical and digital literacy. In that case, the authors brought considerations about the productions that portray the use of GeoGebra software in the development of geometric activities by teachers who teach in the Elementary School.

The authors highlight that those researches were produced between 2017 and 2021 and showed that there was just a 1% of research on the use of GeoGebra, in the Elementary School. The second point of convergence emphasizes that the majority of research conducted with that software, both in teacher training and with teaching and learning experiences with students, took place in a computer laboratory. In the third point of convergence, the articles were based

on a qualitative methodology. Finally, the studies that make up the sample emphasize the contribution of using GeoGebra to improve geometry teaching and learning processes in the early years (Freitas, Manfredo, 2022). The authors warn that GeoGebra does not replace other teaching methodologies, but instead it adds up to the learning for the teaching of geometry.

Santana (2022) produced the paper entitled *O TPACK e a avaliação de tecnologias digitais no contexto da formação docente* [TPACK and the assessment of digital technologies in the context of teacher training], which addresses ongoing training, whose objective was "to identify and understand how teachers who teach mathematics in the Elementary School (ES) deal with the use and evaluation of Digital Technologies (DT)" (p. 1). The methodology is based on action-research from a dialogical, participatory, and collaborative perspective.

The theoretical framework is a critical perspective on TPACK that aims to articulate pedagogical, technological, and content knowledge. The paper was the result of a master's degree research in which the authors brought as partial results the bibliographic review, which addresses the issue of subjectivity and plurality in the process of appropriating digital technologies in order to teach in basic education.

5 Discussion

Based on the description of the results, we have created the Table 2, which presents the teachers training models identified in the ten investigated articles. To facilitate the discussion of the results, the works have been interpreted and classified, according to the training model presented in the development of each research.

Table 2: Classification of the articles, according to teachers training models

Training Models	Articles	Total	How the training model is presented	
Technical Profissional		0	implicit	explicit
Reflective Profissional	[a1], [a2], [a3], [a5], [a6], [a7] e [a8]	7	[a1], [a2] [a3], [a4], [a5], [a6], [a7] [a8], [a9]	0
Reflective Critical Intellectual		0		
Transformative Critical Intellectual		0		
Reflective-Technical Profissional	[a4] e [a9]	2		
Not identified	[a10]	1		

Source: Own elaboration

Among the ten articles analyzed, one [a10] did not present a teachers' training model. We have not identified any paper with the technical professional or critical intellectual training model. We have interpreted seven articles [a1], [a2], [a3], [a5], [a6], [a7], and [a8] that presented the implicit reflective professional training model, and two papers, [a4] and [a9], a hybrid between the models, which we have classified as an implicit reflexive-technical model.

We have been unable to interpret the formative model of [a10], as not enough elements were presented. The papers [a4] and [a9] implicitly presented the reflective-technical professional model. The articles portray the exploration of technical knowledge of DICT aligned with the promotion of specific knowledge of mathematics, such as geometry for the training of teachers. However, they present reflections on the importance of using DICT to

teach mathematics content, as a way of offering digital and mathematical literacy. The reason for naming these two articles as reflective-technical is that the reflection was restricted to the uses of technical tools promoted by DICT.

Therefore, the paper [a4] announces a teachers training based on the exploration of technical knowledges. Learning the Kturtle software focuses on the guidelines of a manual, when it describes: "after building it on the computer, with the step-by-step commands, the multiplier presented the REPEAT command to the teachers" (Nogueira, 2013, p. 6). However, there were reflective moments of training that allowed us to understand that the research contained elements characteristic of both the technical and the reflective models.

An example can be highlighted on page five of the article [a4] in the item: *Invitation to a "Volunteer Turtle"*, when the authors of the article emphasize that the multiplier explores the teachers' prior mathematics knowledge when choosing a volunteer to be the turtle. In other words, it explores the knowledge of the software and the mathematics as well, before even using it on the computer. At that moment, teachers say the commands necessary to move the "turtle" from one point to another, established by the multiplier, and which will later be used to develop their activities in the Kturtle software. Furthermore, the multiplier, at the same time, led to the exchange of information and to the paper in collaborative groups. Another key point was the sharing of suggestions of future activity among teachers.

The paper [a9], also, presents the reflective-technical professional model. The authors report what the place should be like to project the digital whiteboard, and to lay the assembly details and the use of the resource. Thus, we have identified the characteristics of the technical model, in the report of how the teachers training had been planned and conducted:

> [...] the technical components were explored so that the blackboard could be used: computer, multimedia projector, CD for installing the software, [...] Afterwards, the teachers were shown the features of the blackboard [...] It was also discussed about the need to think about the organization of the classroom space, for example, using a clean wall to project the screen, and taking care to install the blackboard at a height that students could also reach and interact with it. Another technology was also explored in this workshop, the Base Blocks application (Blauth, Scherer and Corrêa, 2019, p. 8).

In that sense, that paper advocated a training based on procedures that aim to provide guidance on the technical knowledge of resources. However, there are moments of reflection on the implications of using those resources in line with mathematics learning, as well as encouraging the use of the computer room.

In relation to the reflective model, we have found that in most of the articles analyzed, [a1], [a2], [a3], [a5], [a6], [a7] and [a8] it appears, implicitly, since the authors do not make the teacher training model clear. However, it was possible to interpret and to identify such model because the papers have characteristics of interventions with the purpose of reflection in teaching practice.

Therefore, we have identified in the paper [a1] the reflective model, visible through the description of the actions which had been developed in the training. The teachers were divided into groups to prepare the short film, which took place through a guideline for the activities, in seven moments, since it was necessary to carry out a theoretical reflection on the chosen subject and, at the same time, frame it within the mathematics content about numbers and measurements. The researchers also propose, in the seventh moment, the socialization of the productions, in which teachers exchange experiences, reflect on the knowledge mobilized, the technological knowledge of mathematical content and the textual genre "cinematic script", in

addition to reflecting on their practices before adding DICT, and how they can have a positive impact on the activities so that they become more productive.

Article [a2] presents the reflective model. We have observed its characteristics as it points out that the training proposal is "to establish a dialogue between the theoretical and the methodological studies and the teaching practice so that the teacher recognizes him/herself as a reflective and an active subject in the training action" (Paula *et al*., p. 60). That training has been proposed with the aim of offering geometry teaching, even in the face of emergency remote teaching, and for such a purpose it relied on the use of digital technological resources in a reflective way.

The paper [a3] presents the results of analysis of a continued training in the remote model, based on mathematical and digital literacy. It does not explicitly present the teacher training model. However, we interpret it as a reflective professional training model. Data collection has been achieved through the recordings of the subjects' speeches during the training, the results of which showed that the participants received guidance via Google Meet, then were divided into groups on WhatsApp, and, in each group, there was a leader, who helped with the reflection about the activities which were being carried out.

The paper [a5] addresses the reflective training model. It points to gaps in the public policies to include the use of DICT in the educational space, based on a critical analysis of the One Computer per Student program. They believe that continuing education cannot be limited to just one training that leads the teacher to use the resources of a program, but it goes beyond the use of such a software, establishing continuous practices of digital inclusion and socialization of DICT so that "it can reveal the need for advancement and changes in ways of thinking and producing knowledge at school, for the student and with the student, highlighting possibilities for a technological education for the teacher" (Orlovski *et al*., 2013, p. 9).

The paper [a6] implicitly presents the reflective professional model. The researchers report that teachers have learned to use DICT by developing activities for the students: "in those meetings, the participating teachers carried out and developed activities in the Compass and Ruler 4, SketchUp5 and Construfig3D6 software, which explore both flat and spatial geometric figures, for later application in their classes" (Vieira and da Costa, 2016, p. 5). Thus, the authors consider, through the evaluation of that training, that the implications of using technological resources can point to "needs for advances and changes in the way of producing knowledge at school" (Vieira and da Costa, 2016, p. 9). That has occurred because by proposing training based on the development of the activities involving geometry contents for their students, it showed that in-service training provides the movement towards appropriation of knowledge of the technological contents. The authors highlight the importance of continuing proposals for training and consider that such a concern may permeate the "scopes of Brazilian public policies for teacher training" (Vieira and da Costa, 2016, p. 11).

The paper [a7] presents the reflective training model for teachers and it has a bias towards the theoretical framework of the theory of complexity. The authors justify the importance of promoting digital literacy so as not to rely solely on the technical use of digital resources. They chose to use the Minecraft game, which takes the form of construction games indicating the learning of mathematical knowledge, that is, it stimulates intellectual cognitive skills. They explain that "hereby, the challenge of proposing a character of reflection in the action, of demystifying what digital literacy is, and how it impacts their teaching identity" (Souza and Guérios, 2019, p. 8).

The research [a8] presents the reflective model. The paper describes a training project

based on Flick's critical theory. That proposal came from a problem highlighted by the evaluation of the use of DICT, in a school, in the context of the pandemic, caused by Covid-19. Teachers used digital technologies but did not have knowledge of the technological pedagogical content — TPACK. Based on that problem, researchers have established strategies to transform the culture of teachers and students in favor of a critical use of Digital Information and Communication Technologies (DICT), which included continuing training programs and the creation of innovative learning environments, promoting a reflective and meaningful integration of technologies. However, despite the research declaring a critical use of technologies, there was no in-depth analysis or mention of the influences of social, political, and economic elements on the development of training, thus reducing it to a reflection only on the didactic issues of using DICT in the classroom.

In short, most of the papers analyzed brought a training perspective in the reflective training model, which is limited to reflections on teaching activities that involve DICT in teacher training and its implications for pedagogical practices. The studies analyzed that have implicitly used the reflective model are those that:

> for which the solutions already accumulated in their repertoire of cases are not valid. Those are situations for which, in principle, there is not even an adequate way of interpreting them, so that it is necessary to simultaneously understand the situation and modify it. Such double need leads them to take actions on the situation that they can evaluate, that is, they examine the situation. Thus, the evaluation-action-new evaluation spirals are set in motion (Contreras, 2012, p. 110).

However, it is important to emphasize that criticisms of the reflective model do not completely deny its usefulness, but emphasize the importance of a more comprehensive and critical approach to the training of teachers.

Ou seja, que vai além da reflexão sobre o uso das DICT na prática pedagógica, a sua contribuição para a promoção dos conteúdos escolares, pois o letramento digital torna-se restrito aos problemas pontuais de sala de aula. In other words, it goes beyond reflection on the use of DICT in pedagogical practice, its contribution to the promotion of school content, as digital literacy is not restricted to specific classroom problems, it encompasses philosophical, historical and political issues of establishment and constitution in Society

An alternative to the reflective model is the critical intellectual, which unfortunately in the present study, we have not found any research in that perspective. However, the critical intellectual model is seen as a more appropriate response to face the complex challenges and contemporary demands of education (Queirós, 2012). That model emphasizes the importance of a solid theoretical basis and critical reflection on pedagogical practices, aiming for social transformation and a fair and more inclusive education. The professional relies on theory to question and criticize problems associated with social, economic, political and cultural conditions with the aim of promoting facing and overcoming problems.

6 Final Considerations

Considering answering the research question *What are the training models that shape research on the training of teachers who teach mathematics in the Elementary School using DICT?*, we have identified in these articles that the reflective professional model is the formative model which prevails in most teacher training proposals. However, the papers do not support or explain that model, through reflective theoretical references, which demonstrates theoretical fragility. In view of the above, we point out that as a demand to be faced in the field

of teacher training related to the DICT theme.

We consider the result to be apprehensive, due to the fact that that model does not promote transformative education, nor does it have elements that enable a critical reflection of reality, through social, political, and economic elements. The paper is based on a specific reflection on teacher training processes with DICT and, in some cases, in connection with the basic education. Therefore, such reflective training model does not consider the problem or conflict from a social, economic, political, and cultural point of view, and does not have the capacity to promote intellectual transformation and power relations in the society.

However, there is a need to disseminate, in teacher training, a training model which goes beyond the reflection about the practice, and which leads them to engage in a deeper and more critical analysis of digital and mathematical literacy. An alternative is the transformative critical intellectual model. However, in the analysis of the ten papers here investigated, we did not identify any research that have used the critical intellectual formative model, as it becomes an important demand in the context of DICT studies, given that, in current times, the experience of digital culture, in addition to teaching strategies, it contributes to the spread of information, and misinformation, on social networks, which has an impact on people's lives and on the educational process.

Other problems, such as the lack of digital resources in schools and students' homes, together with the lack of support from public policies, impact the teaching practice and the achievement of digital literacy. In this way, we need to question, to debate, and to modify such a reality, through research, promotion of continued training, and struggle for the implementation of public policies, which will enable social and intellectual transformation in the social, political, and cultural dimensions involved in teacher training with DICT. Thus, in order to face such problems, the teacher training in the critical intellectual model is necessary and it is the main demand highlighted by this research.

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