Article

The impact of digital technologies in teachers' initial training on their pedagogical practices

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Abstract
This work aims to analyze the research developed at national and international level on the impact of the integration of digital technologies in initial teacher training on pedagogical practices. For this purpose, a systematic review of the literature was carried out in order to conduct a survey of experiences in the last 10 years, in order to evidence its main results, thus contributing with new research in the context of initial teacher training for the integration of digital technologies. The results were categorized, in this study, within three categories of analysis: a) reviews of literature and educational programs in the field of initial teacher education for the use of digital technologies; b) experiences and practices in the field of initial teacher training for the use of digital technologies and c) initial teacher training with emphasis on digital skills. This study illustrates practices, challenges, indications and recommendations to the field of study, pointing out that the reflection about a training curriculum anchored in digital competency guidelines can be a viable path for the positive impact of the insertion of digital technologies in the pedagogical practices of teachers, and that previous experiences that indicate levels of digital skills need to be valued and worked on in teacher training to qualify their transposition from entertainment or personal use to a formal context of education that presupposes intentionality and clear learning objectives.

Keywords: Initial teacher training, Pedagogical practices, Digital technologies.

1. Introduction

This study aims to analyze national and international research on the impact of the integration of digital technologies in initial teacher training on their pedagogical practices, in order to systematize indicators about the possible impact in this field. To do so, we conducted a systematic literature review to identify the scientific contributions on the topic in question.

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The integration of digital technologies in the educational field involves many aspects, among which the importance of initial teacher training stands out. Technology can be present as an object of study in the course syllabus or as a means of communication, organization, access, and sharing of information used in an integrated way with the methodological procedures developed throughout the training.

Digital technologies, when related to initial teacher training, raise reflections about the nature of this training, leading to reflections about the extent to which the experiences of studying and integrating these technologies contribute to future teachers effectively integrating them into their pedagogical practices. While analyzing this relation, Alonso (2008) points out that the logic established by digital technologies in the educational field requires work developed in a network, a work that goes far beyond the practice in schools, and also warns that the use of sophisticated resources has not guaranteed changes in pedagogical practices. Beyond "use", the term "integration" tends to overcome the instrumental level of technology use, which fails to recognize the pedagogical potential and has been used merely as a means of passing information/content to students (RAO, 2022).

Thus, we support Silva, Bilessimo and Machado (2021) when they state that one of the points that deserves attention is the way this inclusion has been carried out in the teaching process. The integration of digital technologies into pedagogical practices is truly realized when these are part of the routine of the classroom environment, thus supporting the curriculum, learning goals and objectives, being planned and intentional, engaging students with the content and with the construction of knowledge, and facilitating collaboration inside and outside the classroom (RAO, 2022).

Thus, the integration of digital technologies involves specific competencies of the teachers in relation to their pedagogical integration, thus teachers must acquire and develop, in their training and professional career, knowledge, skills, and attitudes pertinent to the inclusion of technological resources in their planning and daily practice. From this perspective, it is possible to list different pedagogical models for integrating digital technologies into teaching and learning processes. Among the models cited in the literature, we can highlight some of them: Apple Classrooms of Tomorrow Today (ACOT)[3]; Constructivist Learning Environments (CLEs)[4]; Five Stage Model of E-learning

[3] Efficient teaching and learning model with technological support, dissemination of innovation, and professional development of teachers. The phases that make up the model are: a) Introduction: learning the basic concepts of technology use; b) Adoption: supporting traditional teaching with the use of technology; c) Adaptation: integrating technology into existing classroom activities; d) Appropriation: generating new approaches to teaching and learning that make use of technology; e) Innovation: discovering completely new uses for technological tools.

[4] A model that mainly aims to promote problem solving and the development of concepts, emphasizing the role of students in the construction of knowledge (learning by doing). It uses instructional design as a model for designing environments that can engage students in the development of knowledge.

(FSM)[5]; Online Interaction Learning Model (OILM)[6]; Substitution, Augmentation, Modification and Redefinition (SAMR)[7], and Technological Pedagogical Content Knowledge (TPACK)[8] (SILVA; BILESSIMO; MACHADO, 2021). These theoretical models aim to explore knowledge that a teacher needs for pedagogical practice in a learning environment equipped with digital technologies. However, it is not the aim of this study to delve into each of these models, but it is important to reflect on which dimensions are involved and can be integrated into these models in order to qualify the processes and contexts of teacher education.

Therefore, this paper presents the results of the systematic review, by highlighting contributions, barriers, and developments experienced in initial teacher training that may influence the integration of digital technologies in pedagogical practices.

2. Initial Teacher Training for the Integration of Digital Technologies into Pedagogical Practices

In view of the mystification of the topic, the increase of academic research on initial teacher training is noticeable (GATTI *et al.*, 2019; ANDRÉ, 2010; 2020). Authors such as Nóvoa (2017), Gatti *et al*. (2019), André (2010; 2020) and Freitas (2007, 2010) contribute to the context of teacher training, by addressing reflections about the importance of reconstructing training course curricula and building a new institutional site for training. Some topics stand out in the studies, among them: the absence of a specific national policy, articulated and directed to the best qualification of initial teacher training in any modality; fragmented curricular structures, without articulating disciplines, with generic syllabus as to pedagogical knowledge and with visible abbreviation of training; curricular internships without projects and institutional support, and with precarious monitoring and evaluation, *etc*. (GATTI *et al*., 2019).

According to André and Martins (2020), initial training courses need to be constantly rethought and restructured in view of the real contexts in which they are developed, taking into account, for example, the very profile of the students who attend these courses, often with precarious school trajectories, expectations, and dispositions that challenge teacher educators to review their conceptions and reinvent their teaching practices.

In this context, the authors state that the separation between theory and practice never seems to be resolved. Gatti *et al*. (2019) state that there has

[5] The Model consists of five stages or phases to develop virtual learning with the help of a moderator. Its structure represents a ladder in which each step expresses the academic, technical, and moderation skills involved in virtual learning where they all relate to each other through the interaction between its elements.

[6] Model that has been applied as a theoretical reference for online courses and as a techno-pedagogical model in higher education. The model is based on the constructivist learning theory and interactions take place through collaborative learning.

[7] It consists of a 4-level hierarchical set that allows you to evaluate how technologies are used by teachers and students in class. Its aim is to help teachers evaluate how they incorporate technology into their classrooms in order to understand what kinds of technology uses have a greater or lesser effect on the learning process.

[8] Technological Pedagogical Content Knowledge (TPACK) is considered a set of strategies that integrate technologies in the classroom. It is a theoretical model formulated to understand and describe the types of knowledge necessary for a teacher for pedagogical practice in a technology-equipped learning environment.

always been difficulty in establishing a curricular balance between knowledge related to the specific area of teaching and pedagogical knowledge related to educational practices aimed at basic education. However, regarding this, it should be noted that this concern is in force in the current National Education Plan (*Plano Nacional de Educação*, PNE) (BRASIL, 2014), which includes in its aims the need to requalify the Pedagogy courses and other licensure degrees in order to approach the real demands of Basic Education.

The principles of the Brazilian Policy for the Training of Basic Education Teaching Professionals (*Política Nacional de Formação de Profissionais do Magistério da Educação Básica*) include the articulation between theory and practice in the teacher training process, based on the mastery of scientific and didactic knowledge of teaching, as well as, according to the Brazilian National Common Core Curriculum (*Base Nacional Comum Curricular*, BNCC), training must be based on three dimensions: knowledge, practice, and engagement.

It is worth pointing out that initial teacher training has been carried out in both face-to-face and remote learning modalities. However, remote learning has grown exponentially in recent years, as we can see in the last census, which showed that the number of students enrolled in remote learning was higher than the number of students enrolled in face-to-face courses, and also showed that most remote learning students attend undergraduate licensure courses and are female (DIRETORIA DE ESTATÍSTICAS EDUCACIONAIS, 2018).

The expansion of the remote learning modality indicates the numerous challenges to initial and continuing teacher education courses (CERDAS *et al.*, 2013). Among some weaknesses in the field of distance education, especially in initial teacher training, authors such as Shiroma and Evangelista (2015) and Pesce (2009) criticize the expansion of Distance Education (DE) in teacher training, by pointing out that many educational institutions, guided by the cost-benefit ratio, prefer to train teachers en masse, often without the quality required for teacher training. Gatti *et al*. (2019) have been discussing for years the fast-paced conversion of face-to-face courses into distance learning courses and the excess of institutions offering courses in this modality.

In light of this, it is important to reflect on teacher training that values the appropriation of knowledge relevant to human life, that has political commitment, thus making it possible to go beyond the knowledge inherent to the domain of methodologies and practices, to provide for a cultural and humanistic educational process, able to understand and problematize different social realities (GATTI *et al.,* 2019). Thus, it is essential to reflect on an initial teacher training for the integration of digital technologies, which is the focus of this study, that has cultural ties, political commitment, and is committed to the emancipation of educators and students, as opposed to the predominance of an instrumental reason of reality, as Pesce (2009) mentions. In this sense, research conducted by Silva *et al*. (2018; 2019) has attempted to understand teacher training processes that include encouraging reflection and integration of digital technologies into pedagogical practices.

Based on these assumptions and aiming, in this study, to reflect about initial teacher training, it should be noted that, in Brazil, Resolution No. 02/2019 (BRASIL, 2019), dated December 20, 2019, defines the National Curriculum Guidelines for the Initial Teacher Training for Basic Education and establishes the Brazilian National Common Core Curriculum for the Initial Training of Basic Education Teachers (BNC-Training). This resolution provided a regulatory

reference framework for quality assurance in teacher training courses. Based on it, the benchmarks of professional competencies were determined, thus standardizing a set of skills necessary for the teacher training process.

Among the skills required of every teacher graduating from initial training courses are those related to digital technologies in the formative process. Among the 10 general competencies described in the document is the 5th one, which mentions the need for future teachers to understand, integrate, and create digital technologies in a critical, meaningful, reflective, and ethical way in their practices, as well as to integrate them as a pedagogical resource and as a training tool to communicate, access, and disseminate information, thus producing knowledge, solving problems, and enhancing learning. In addition, its specific competencies include some related skills, such as: integrating appropriate digital technologies into teaching practices; performing educational curation, through digital technologies, virtual content, and other technological resources; incorporating digital technologies into pedagogical practice to enhance and transform students' learning experiences by stimulating an investigative attitude; promoting the ethical, safe, and responsible use of digital technologies; and knowing how to communicate with all stakeholders: colleagues, parents, families, and the community, integrating information and communication technologies, among other resources.

When reflecting on pedagogical practices for the use of digital technologies, teacher training is one of the challenges to overcome. According to Coutinho (2009), it is necessary to consider teacher training that is able to combine digital technologies with educational theory and practice, thus providing the teacher with a new pedagogical posture regarding curriculum organization, learning mediation, and the methodologies that are implemented in the classroom.

Some time ago, Bévort and Belloni (2009) mentioned some assumptions that they claim have been characterized as barriers for the field of study in question, such as: the integration of digital technologies into classroom practices with an instrumental emphasis, the lack of reflection on the messages transmitted, and on the subject in teacher training. This reality seems to remain and is not restricted to Brazil, as Lillejord *et al*. (2018) note that, in several countries, the integration of digital technologies into pedagogical practices and the development of skills for their integration in teacher training has not been an effective reality. However, we reiterate that initial training may be only one of the obstacles, as there are many others, such as the lack of articulation between the university, schools, and public policies (NÓVOA, 2017); the lack of technological structure in schools (SILVA, 2018); teachers' lack of confidence in adapting their pedagogical practices, as well as the need for an agreement of intentions converging with society to define policies committed to the sustainability of initiatives, among others (CIEB, 2019).

Reflecting on initial teacher training for the integration of digital technologies in the current context leads us to ask: how can we expect future teachers to incorporate new digital resources into their pedagogical practices if many do not experience them during their initial training? According to Sanabria Rodríguez (2014), initial teacher training is often restricted to reading and discussing texts through traditional, expository lessons and seminars. In this regard, the author advocates the adoption of digital technologies in all subjects provided for in the curriculum, and not only in those that specifically discuss the

topic, because, by experiencing initial training with the integration of digital technologies as students, they may glimpse possibilities for the future moment in which they will have classes under their responsibility.

Some studies analyze the integration of digital technologies in teacher training through documentary research to see how they have been covered and planned in pedagogical practices. According to Alves (2008), they seem to be used for planning and organizing lessons more than for interacting in pedagogical practices. Gatti and Nunes (2009) presented a study on the curricula of 31 licensure mathematics courses in Brazil, in which they verified that only 29% of these courses have subjects that contemplate digital technologies in education.

In this respect, we can indicate the research by Silva *et al.* (2019), who conducted a documentary research about the educational projects of seven distance learning licensure degrees promoted by the Open University of Brazil of the Federal University of Santa Catarina (Universidade Aberta do Brasil da Universidade Federal de Santa Catarina). The results of the research showed that, in many cases, the documents that guide teacher's distance education contained not only the instrumental aspects related to the integration of technologies in the classroom, but also the pedagogical and critical aspects of the use of technologies in education. This corroborates the evidence that their creative, constructive, reflective, and critical integration constitutes a training possibility for the use of digital technologies as an alternative to promote significant changes in the learning process of future teachers.

In addition, Barcelos, Passerino and Behar (2010) present a case study on the implementation of the subject Mathematics Education and Technology (EMT) in the syllabus of the Mathematics licensure course at the Fluminense Federal Institute (Instituto Federal Fluminense). The authors aimed to investigate the impact of the actions developed in this subject on the teaching practice of the graduates. Based on the analysis of the interviews with the graduates, the conclusion was that a good quality initial training was not enough for digital technologies to be incorporated into teaching practices.

As Coutinho (2009) states, few schools have been able to experience innovative practices capable of expanding the learning environments beyond the formal classroom, thus eliminating the barriers of time and space, and creating and developing real learning communities. Therefore, "how to provide training that can lead future teachers to integrate digital technologies into the classroom?" (COUTINHO, 2009, p. 76). In this regard, it is worth questioning: What is the role of initial and continuing education and public policies in the development of innovative practices? As previously mentioned, among other premises, the articulation between universities, schools, and public policies seems to be essential, and requires an agreement of converging intentions between both and society for the definition of policies committed to the sustainability of these practices (CIEB, 2019; NÓVOA, 2017). In line with this perspective, we emphasize the importance of initial teacher training for the integration of digital technologies in teaching practices. However, not simply an instrumental integration, but an integration that is transversal to teaching, which encourages innovative teaching practices and ensures improvements in the learning process, diversity of methods, and pedagogical proposals.

In this regard, Garcia *et al*. (2011) pointed out that access to digital technologies in teacher training processes can significantly help in the preparation and training for their didactic use, because, by experiencing such

moments, students will be able to understand them more easily and be confident enough to integrate them in the future. From such experiences may emerge some dimensions that are part of pedagogical practice for the use of digital technologies in education, such as the pedagogical dimension, professional dimension, and citizen dimension (CIEB, 2019).

Therefore, reflections about the adequacy of curricula and new proposals for initial teacher training for the use of digital technologies are necessary. For this purpose, the reflections need to take into consideration important concepts to the field of study, such as: media literacy, digital literacy, and digital skills of future teachers.

Media literacy is not only considered to be what one can do with print media, but also with other media. Just as someone who can read but not write is not traditionally considered literate, we should not assume that someone who is media literate can consume but not communicate through media (JENKINS, 2009). Digital literacy (*letramento digital*, in Portuguese), on the other hand, can be depicted through the understanding of complex networks of social practices with the use of digital devices that support, intertwine, contest, and modify each other through Information and Communication Technologies (ICTs). Digital literacy aims at the appropriation of skills so that the individual can be literate in different languages in the digital context (visual, musical, mathematical, *etc.*), and in other ways that are essential to communicate, express feelings, ideas, and experiences in virtual environments (BUZATO, 2007). Complementarily, digital literacy (*literacia digital*, in Portuguese) is considered the educational and training process which does not only refer to the actual ability to integrate digital resources, as it encompasses the sociocultural and situational dimensions that impact the lives of individuals (AIRES; PALMEIRO; PEREDA, 2019).

Given these conceptual frameworks, it is worth noting that, according to Silva and Behar (2020), the definition of digital skills is a concept that goes beyond these literacies, as it is considered a complex concept that involves a set of knowledge, skills, and attitudes that must be mobilized, so that the subject acts through technologies (SILVA; BEHAR, 2020) in order to develop critical, collaborative, and creative learning in the classroom (CIEB, 2019). Additionally, Silva and Behar (2020) mention that a digitally competent subject is expected to have a sufficient understanding of technology so as to be able to use information, be critical, and communicate by integrating a variety of digital tools.

Corroborating such statement, Coll, Mauri, and Onrubia (2008) point out that, although digital technologies can be considered efficient tools to improve students' education, it is necessary to transform teachers' performance, considering that learning is related to the quality of classroom practices.

Considering this, we aim to understand the impact of digital technologies in initial teacher training on their pedagogical practices.

3. Methodology

We conducted a systematic review, considered secondary studies that have primary studies as their main source of data. Primary studies are scientific articles that report first-hand research findings (GALVÃO; PEREIRA, 2014, p. 183). The method used to prepare the systematic review followed these steps: 1) elaboration of the research question; 2) literature search; 3) selection of articles; 4) data extraction; 5) assessment of methodological quality; 6) synthesis of data

(meta-analysis); 7) assessment of the quality of evidence, and 8) writing and publication of results (GALVÃO; PEREIRA, 2014).

The systematic literature review by searching the research sources and selecting the publications according to the inclusion and exclusion criteria, as well as quality assessment, took place from May 30 to August 30, 2019.

The research sources used are according to Table 1:

Table 1 - Research sources

Source	Acronym
http://www.scielo.org	SciELO
http://eric.ed.gov/	ERIC
https://www.scopus.com	Scopus
www.sciencedirect.com	Science Direct

Source: The Authors (2020).

To conduct the search in the research sources, we used the following search strings: ("*teacher training*" OR "*teacher development*" OR "*teacher formation*") AND ("*practice pedagogical*" OR *teaching* OR *classroom* OR *school*) AND (*technology**).[9] The different colors presented in Table 1 aim to relate the articles found in each research source to the other tables in this paper.

The inclusion criteria were as follows: a) articles containing initial teacher training experiences on the use of digital technologies in pedagogical practices; b) literature reviews or systematic literature reviews on the topic; c) publications between 2008 and 2020; d) full text availability; e) texts available in Portuguese, English, and Spanish; and e) title and/or abstract containing the search strings.

At the same time, the exclusion criteria were: a) repeated articles; b) research prior to 2008 and c) title and abstract without any of the selected words or different from the context of the research.

The study was composed of 3 stages: 1) broad results presented in the search platforms described according to the selected keywords and filters, 2) reading of the titles and their abstracts considering the previously defined inclusion and exclusion criteria, and 3) reading of the full articles and assessment of their quality, with the aim of selecting the studies whose main topic was initial teacher training for the use of digital technologies in pedagogical practices.

The quality assessment followed these criteria: a) the publication has been peer-reviewed; b) detailed description of the procedures used in interventions (when applicable), data collection, and data analysis; c) indication of coherent theoretical references related to the research topic and results; d) description of the results in an organized, clear, and objective manner; e) a qualified analysis with no unsupported interpretations of the data presented.

After quality assessment of the selected articles, we categorized the data according to the analysis of the research aims of each article.

[9] The Boolean operator "AND" searched the intersection between these two terms, and the operator "OR" broadened the search possibilities in the databases. The Truncation feature represented by the asterisk (*) symbol to the right of the word was used to replace any number of characters in the searched words. Double quotation marks were used for the exact compound terms searched.

4. Results

In the first stage of the research, we found 1,183 articles, which we selected respectively according to the stages of the research. Table 2 shows the number of studies that we found and selected during each stage of the research for this systematic review:

Table 2 - Number of articles selected in each stage of the systematic review

Database	Stage 1	Stage 2	Stage 3
SciELO	81	14	09
ERIC	204	22	13
Scopus	883	57	17
ScienceDirect	15	2	1
Total	1.183	95	40

Source: The Authors (2020).

Considering the results of the systematic review, we thoroughly analyzed 40 articles in the search for evidence, perspectives, and possibilities of using digital technologies in initial teacher training in pedagogical practices. In order to synthesize the discussion of the data, we defined three categories of analysis: a) reviews of the literature and educational programs in the field of initial teacher training for the integration of digital technologies; b) description of experiences and practices in the field of initial teacher training for the integration of digital technologies and c) initial teacher training with an emphasis on digital competencies. These categories are in Table 3, which describes the articles classified into each of them with their respective years of publication and the databases they were found in.

Table 3 - Categorization of the analyzed articles

Category	Title	Authors (year)
Literature and educational program reviews	Tecnologías digitales: análisis de planes de profesorado de Uruguay.	CABRERA BORGES, Claudia *et al.* (2018)
	As barreiras da prática docente no uso das tecnologias de informação e comunicação.	SCHUHMACHER, Vera Rejane Niedersberg; ALVES FILHO, José de Pinho; SCHUHMACHER, Elcio (2017)
	The Integrative Model of Behavior Prediction to Explain Technology Use in Post-Graduate Teacher Education Programs in the Netherlands.	ADMIRAAL, Wilfried *et al.* (2013)
	Novas formas de aprendizagem: formação de professores no uso das TIC.	HERNÁNDEZ, Ronald; ORREGO CUMPA, Rosalina; QUIÑONES RODRÍGUEZ (2018)
	Students in a Teacher College of Education Develop Educational Programs and Activities Related to Intelligent Use of the Web: Cultivating New Knowledge.	WADMANY, Rivka; ZEICHNER, Orit; MELAMED, Orly (2014)
	Status of Elementary Teacher Development: Preparing Elementary Teachers to Deliver Technology and Engineering Experiences.	ROSE, Mary Annette *et al.* (2017)

Experiências e práticas no campo da formação inicial	TIC y formación inicial de maestros: oportunidades y problemas desde la perspectiva de estudiantes.	MARTÍNEZ, Rosana *et al.* (2016)
	Cinema, prática de ensino de história e geografia e formação docente: produção de curtas-metragens - experiências e estudos de caso.	PERINELLI NETO, Humberto; PAZIANI, Rodrigo Ribeiro (2015)
	La formación de profesores universitarios en la aplicación de las TIC.	LOPEZ DE LA MADRID, María Cristina; CHAVEZ ESPINOZA, José Antônio (2013)
	Formação inicial de professores em tempos de TDIC: uma questão em aberto	LOPES, Rosemara Perpétua; FÜRKOTTER, Monica (2016)
	Methodology in Training Future Technology and Engineering Teachers in the USA.	ANDROSHCHUK, Iryna; ANDROSHCHUK, Ihor (2017)
	"It's about Improving My Practice": The Learner Experience of Real-Time Coaching.	SHARPLIN, Erica; STAHL, Garth; KEHRWALD, Ben (2016)
	A corporate partnership to enhance teacher training.	FINE, Bethann (2012)
	Developing Practice: Teaching Teachers Today for Tomorrow.	MAYS, Tony John (2011)
	Formação de professores para usar e produzir recursos educacionais abertos: uma abordagem vantajosa para todos.	MISRA, Pradeep Kumar (2012)
	Pre-Service Teacher Training on Game-Enhanced Mathematics Teaching and Learning.	MELETIOU-MAVROTHERIS, Maria; PRODROMOU, Theodosia (2016)
	Visualisation in Basic Science and Engineering Education of Future Primary School Teachers in Human Biology Education Using Augmented Reality.	FUCHSOVA, Maria; KORENOVA, Lilla (2019)
	The importance of attitudes toward technology for pre-service teachers' technological, pedagogical, and content knowledge: Comparing structural equation modeling approaches.	SCHERER, Ronny *et al.* (2018)
	ICT integration in mathematics initial teacher training and its impact on visualization: the case of GeoGebra.	DOCKENDORFF, Monika; SOLAR, Horacio (2018)
	La clase invertida en la formación inicial del profesorado: acercando la realidad del aula de matemáticas.	CID, Ana Isabel; CID, Rocío Guede; RODRIGUEZ PIÑERO, Piedad Tolmos (2018)
	Implementing Teachers' Training Technologies at a Federal University: E-portfolio, Digital Laboratory, PROLog Module System.	SMOLYANINOVA, Olga; BEZYZVESTNYKH, Ekaterina (2019)
	Aprendizaje Basado en un Proyecto Docente: Aprendizaje, creatividad, innovación y nuevos roles en la formación de profesorado en la era digital.	DE LA IGLESIA VILLASOL, Mª Covadonga (2018)
	Fluência tecnológico-pedagógica na produção de Recursos Educacionais Abertos (REA) /	BAGETTI, Sabrina; MUSSOI, Eunice

	Technological-pedagogical fluency in the production of Open Educational Resources (OER).	Maria; MALLMANN, Elena Maria (2019)
	Laboratório virtual para a Unidade Terra e Universo como parte da Educação Universitária de Professores de Ciências.	FAUNDEZ, Claudio *et al.* (2014)
	L'ensenyament de les ciències socials i el tractament de la informació. Una experiència amb l'ús de webquests en la formació del professorat d'educació primària.	MARTÍNEZ, Pedro Miralles; CARRASCO, Cosme Jesús Gómez; FERRER, Laura Arias (2013)
	The influence of information and communication technology (ICT) on teacher education and professional development in delta state, Nigeria.	OSAKWE, N. R. (2010)
	Information and Communication Digital Technologies and teacher formation in a Contructionist, Contextual and Meaningful approach to generate an inclusive school.	SANTOS, Danielle Aparecida do Nascimento dos; SCHLÜNZEN, Elisa Tomoe Moriya; SCHLÜNZEN, Klaus (2013)
Formação inicial de professores e competências digitais	El aula, espacio propicio para el fortalecimento de competencias ciudadanas y tecnológicas.	MALDONADO, María Eugenia (2018).
	Desarrollo de competencias metacognitivas e investigativas en docentes en formación mediante la incorporación de tecnologías digitales: aportes a la excelencia docente.	SANABRIA RODRÍGUEZ, Luis; LÓPEZ VARGAS, Omar; LEAL URUENA, Linda Alejandra (2014)
	¿Están listos los futuros profesores para integrar las TIC en el contexto escolar? El caso de los profesores en Quebec, Canadá.	KARSENTI, Thierry; LIRA, María Lourdes (2011)
	Analysing teacher knowledge for technology education in primary schools.	ROHAAN, Ellen; TACONIS, Ruurd; JOCHEMS, Wim (2012)
	Classroom ICT integration in Tanzania: Opportunities and challenges from the perspectives of TPACK and SAMR models.	KIHOZA, Patrick *et al.* (2016)
	An evaluation of technology teacher training in South Africa: Shortcomings and recommendations.	POOL, Jessica; REITSMA, Gerda; MENTZ, Elsa (2013)
	A Quantitative and Qualitative Inquiry into Future Teachers' Use of Information and Communications Technology to Develop Students' Information Literacy Skills	SIMARD, Stéphanie; KARSENTI, Thierry (2016)
	Massive Open Online Courses in the Initial Training of Social Science Teachers: Experiences, Methodological Conceptions, and Technological Use for Sustainable Development.	ORTEGA-SÁNCHEZ, Delfín; GÓMEZ-TRIGUEROS, Isabel María (2019)
	Competencia Digital Docente en los Institutos Superiores de Formación de Maestros: Caso de República Dominicana.	DÍAZ, Roselina Pérez (2019)
	Development of Digital Competence in Secondary Education Teachers' Training.	NAPAL FRAILE, María; PEÑALVA-VÉLEZ, Alicia; MENDIÓROZ LACAMBRA, Ana (2018)

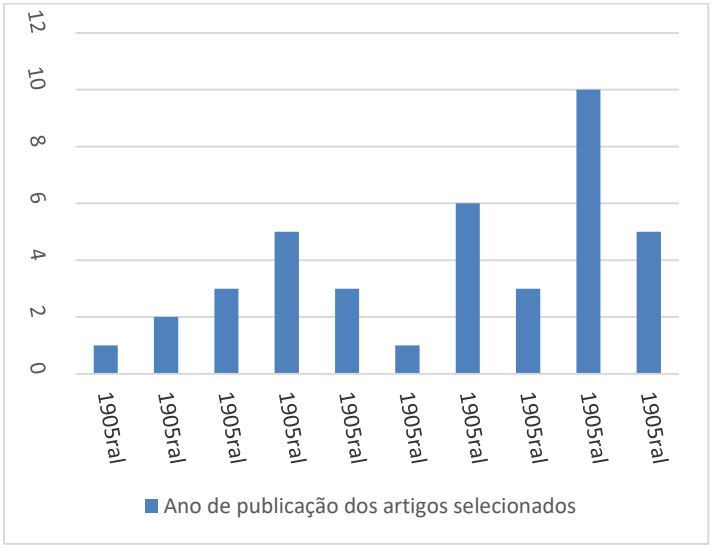
	Flipped classroom para adquirir la competencia digital docente: una experiencia didáctica en la Educación Superior.	SOSA DÍAZ, María José; PALAU MARTÍN, Ramón (2018)
	Particular results of a research aimed at curricula design of teacher training in the area of didactic technological competences.	ZÁHOREC, Ján; HAŠKOVÁ, Alena; MUNK, Michal (2018)
	Formación inicial de docentes en educación básica para la generación de conocimiento con las Tecnologías de la Información y la Comunicación.	LLAMAS-SALGUERO, Fátima; GÓMEZ, Escolástica Macías (2018)

Source: The Authors (2020).

From the categorization, it is possible to observe that 50% of the articles belong to category B (description of experiences and practices in the field of initial teacher training for the use of digital technologies), followed by 34% that are related to category C (initial teacher training with an emphasis on digital competencies), and 15% in category A (reviews of the literature and educational programs in the field of initial teacher training for the use of digital technologies).

Regarding the years of publication, the largest number of articles (n=10) were published in 2018 (as in Graph 1), of which (n=8) were found in the Scopus database, (n=1) in the SciELO database, and (n=1) in the ERIC database. In contrast, in the years 2010 and 2015, we only found (n=1) paper that met the aims of this systematic review.

Graph 1 - Number of articles per year of publication



Source: The Authors (2020).

Regarding the teaching modalities, we can highlight that 90% (n=36) of the researched articles refer to face-to-face initial teacher training. Only 5% (n=02) of the articles address distance learning experiences, and 5% (n=02) refer to blended experiences. It is worth noting that articles on the distance modality were among the 2011 and 2019 publications, and the (n=02) articles featuring blended experiences were both published in the year 2018.

Regarding the countries in which the selected studies were developed, it is possible to state that the studies in category A were conducted in: Uruguay, Brazil, the Netherlands, Peru, Israel, and the United States. As for category B,

the studies analyzed describe experiences and practices carried out in different countries, such as: Uruguay, Brazil, Mexico, Ukraine, Australia, Africa, Cyprus, Slovakia, Belgium, Chile, Spain, and Nigeria. Similarly, the studies in category C describe research conducted in different countries such as: Colombia, Mexico, Canada, the Netherlands, Tanzania, Africa, Spain, and Slovakia.

5. Discussion of the data

Initial teacher training for the use of digital technologies in pedagogical practices proves to be a possibility in the studies analyzed. In order to synthesize the discussion of the data, we defined three categories of analysis:

a) Reviews of the literature and educational programs in the field of initial teacher training for the integration of digital technologies

The studies analyzed point out barriers that can influence the use of digital technologies in pedagogical practices. In this regard, they consider that initial training itself has been one of the mechanisms that produce obstacles in the use of digital technologies by the undergraduates in pedagogical practices, because it does not offer the necessary conditions for overcoming the existing obstacles (SCHUHMACHER; ALVES FILHO; SCHUHMACHER, 2017). However, it is worth noting that initial training may be only one of the obstacles, as there are many others, such as the difficulty or inexistence of a connection and articulation between the university, schools, and public policies (NÓVOA, 2017); the lack of technological structure in schools; poor infrastructure; internet not available or without the necessary speed for an educational practice with the technologies planned; prohibition of cell phone use in schools; lack of institutional support; teachers' struggle to reflect on their own practices (SILVA, 2018), and even the lack of confidence of the teachers themselves to adapt their pedagogical practices in the classroom with the integration of technologies (CIEB, 2019), among others.

In short, in order to overcome these obstacles, great efforts are required from teachers, managers, public policies, and society in general. An agreement of converging intentions with society is required for the definition of policies committed to short, medium, and long-term action plans, thus allowing for the quality and sustainability of the initiatives. According to the CIEB (2019), some changes are necessary, such as: restructuring the spaces and times of the school and the teacher's work; conceptual changes, such as rethinking the conception of curriculum and the understanding of what it effectively means to learn and teach through ICT; reviewing the conception of management, in order to bring it closer to an articulating action between the administrative, technical, political, and pedagogical dimensions inherent to the work of the management teams of educational institutions (CIEB, 2019).

In addition to the obstacles, the study by Admiraal *et al.* (2013) analyzes that the basic integration of technologies in teacher training shows only an instrumental perspective, thus corroborating with the studies by Rao (2022) that point out the need to overcome the instrumental level of technology use that ends up not recognizing its pedagogical potential. For Admiraal *et al.* (2013), therefore, teacher training does not provide results in professional practice, since we can observe that, in fact, teachers have learned more about technology while teaching, during their professional practice, than effectively in training institutions.

In another way, through a document analysis of Initial Teacher Training Programs in the years 2005 (151 programs) and 2008 (238 curriculum documents). Cabrera Borges *et al.* (2018) emphasize that, over the years, documents have overcome an instrumental view of technologies in favor of understanding them in a broader aspect.

Meanwhile, Lopes and Fürkotter (2019) conducted a document analysis of the curricula, syllabuses, and descriptions of 123 teacher training courses at three state universities in São Paulo. The analysis of the curricula indicated the existence of required and optional courses with terms related to digital technologies. However, there were more optional courses and their contents were disconnected from the educational area, methodological resource, and topic of discussion. It was evident, in this study, that mathematics courses give more emphasis on training for its use, having as a common strategy the articulation between the disciplines, guided by technique and practice.

From another perspective, Hernández, Orrego Cumpa, and Quiñones Rodríguez (2018) conducted a systematic literature review of the conceptual aspects of teacher training for the use of these resources and their implications for teachers' daily work. According to the authors, besides the instrumental use, pedagogical knowledge of the use of these resources is a determining factor in the teaching process; however, the socioemotional aspects, perceptions, and attitudes of the teachers are influential factors that will guide their use and integration in their teaching practices.

Studies indicate the lack of a standard of competencies and skills for the use of technologies to be acquired by graduates during their initial training, and they also report that the lack of guidelines for curriculum planning and minimum content of licensure degrees can influence its integration or lack thereof in teaching practices (SCHUHMACHER; ALVES FILHO; SCHUHMACHER, 2017). It is worth mentioning that, in the Brazilian context, some guidelines, such as LDB 9394/96, the National Education Policy (*Política Nacional de Educação*), and some resolutions have focused on collaborating positively with this problem. An example of this is Resolution No. 02/2019, which provides guidelines aimed at ensuring the quality of Initial Teacher Training courses. To this end, the aforementioned resolution presents ten generic competencies necessary for future teachers. Among them is the ability to understand, integrate, and create digital technologies in a critical, meaningful, reflective, and ethical way in their practices, as well as the integration of digital technologies as a pedagogical resource and as a training tool, to communicate, access, and disseminate information, thus producing knowledge, solving problems, and enhancing learning.

Thus, in addition, we should point out that, when including this approach in curricular environments, the transversality of digital technologies in all subjects of the curriculum should be guaranteed (CABRERA BORGES *et al.* 2018), in order to improve the existing practices observed in previous studies, which illustrate a curriculum with isolated subjects in extensive descriptions, in which the theme appears only as a topic presented in a few classes (SCHUHMACHER; ALVES FILHO, 2017).

Among the contributions that the reviewed papers highlight for integrating digital technologies into teacher training, Admiraal *et al.* (2013) reinforces the importance of integrating more school practices into teacher training, especially in the area of teaching with technology, because this approach could qualify

teacher preparation in the short term, but it could also change the structure of teacher training programs.

Initial teacher training articulated with teaching practices, meaningful experiences, and educational interventions in real work contexts prove essential in the selected studies (ROSE *et al.*, 2017; WADMANY; ZEICHNER; MELAMED, 2014; LOPES; FÜRKOTTER, 2019), revealing positive results to the development of future teachers.

In conclusion, the studies analyzed in this category indicate the need to include pedagogical practices with the use of digital technologies integrated into the training curriculum. Reflecting on experiences and practices in the field of initial teacher training can open the window for discussion of perspectives that illustrate this use.

b) Experiences and practices in the field of initial teacher training for the integration of digital technologies

Experiences and practices in initial teacher training for the use of digital technologies have offered the possibility of reflection on pedagogical practice based on its integration, both from the perspective of the students who experience learning using technologies, and from the perspective of the teachers who integrate the use of technologies in their planning as a means of promoting learning and as an object of study and reflection.

It is worth emphasizing, in this category, that, as we observed in the review results, only two studies presented formative experiences and practices for the integration of digital technologies linked to distance teacher training. This fact may be surprising, given two factors: the first refers to the increasing expansion of this teaching modality (CERDAS *et al*., 2013; GATTI *et al*., 2019), and the second is related to the data that show that the largest number of distance learning students are enrolled in initial teacher training courses through licensure degrees (DIRETORIA DE ESTATÍSTICAS EDUCACIONAIS, 2018).

It is noteworthy that research conducted by Silva *et al.* (2019) has focused on understanding the distance teacher education processes that include an incentive for reflection and integration of digital technologies in future pedagogical practices of their graduates. The results of their study show that, in most educational projects of the researched courses, the perspective of integration of digital technologies in the practices of their graduates tends to happen. This demonstrates that, in many cases, distance teacher training provides experiences and experimentation linked to its integration into daily life, contemplating not only the instrumental aspects related to the integration of technologies in the classroom, but also the pedagogical and critical aspects of the insertion of technologies, as well as aspects related to the teaching and learning processes. The study by Silva *et al*. (2019) illustrates and complements the results of the study by Dockendorff and Solar (2018), which points out that the use of digital technologies in the daily practice of future teachers has proven positive in relation to three areas: teaching attitudes towards their integration into teaching practices, curriculum content covered, and their impact on learning.

The assumptions presented in the studies in this category of analysis point out that practices and experiences in teacher training should be grounded in a curriculum that focuses on contexts of practice (MAYS, 2011). To this end, it must promote a formative process that provides confidence (MARTÍNEZ; LEITE; MONTEIRO, 2016), by stimulating the development of technological and

pedagogical knowledge of future teachers, encouraging them to have attitudes of acceptance regarding the use of digital technologies in pedagogical practices, thus resulting in greater self-confidence to use them (SCHERER *et al*., 2018).

Providing a formative process committed to practices and their reflections was the aim of the studies by Perinelli Neto and Paziani (2015), and Cid *et al*. (2018). For example, teaching practices based on production and creation with technological resources and experiences based on the methodology called flipped classroom (CID; CID; RODRIGUEZ PIÑERO, 2018) were able to promote dialogic reflections in the training process. In this regard, it is important to promote opportunities for future teachers to experience real learning scenarios (FUCHSOVA; KORENOVA, 2019).

Among the selected experiences in this category, we can highlight positive results in intervention practices based on: the TPACK framework (MELETIOU-MAVROTHERIS; PRODROMOU, 2016); technology coaching (SHARPLIN; STAHL; KEHRWALD, 2016); technology standards-based programs (ANDROSHCHUK; ANDROSHCHUK, 2017); corporate partnerships (FINE, 2012); technology labs (FAUNDEZ, 2014); virtual learning environments (SMOLYANINOVA; BEZYZVESTNYKH, 2019); project-based learning (DE LA IGLESIA VILASSOL, 2018); proposed authoring, co-authoring, and leveraging of digital resources (MISRA, 2012); and building collaborative spaces (SANTOS, 2013).

As for the results of these experiences, it is worth highlighting positive impacts in the following aspects: improvement of attitudes and perceptions about the use of games in mathematics teaching and finding indicators of transfer and adoption of TPACK in actual teaching practice (MELETIOU-MAVROTHERIS; PRODROMOU, 2016); establishing more connections between theoretical approaches and teaching practices (SHARPLIN et al. 2016); effectiveness of practical training that is ensured through a training program based on Education Technology Standards (ANDROSHCHUK; ANDROSHCHUK; 2017); opportunity to develop and create engaging and interactive lessons through the use of digital tools (FINE, 2012); involvement in professional communities (FINE, 2012); development of collaborative work (FAUNDEZ, 2014); verifiable increased learning related to the application of technologies (FAUNDEZ, 2014); consolidation of digital learning spaces (SMOLYANINOVA; BEZYZVESTNYKH, 2019); creation, coordination, and presentation of diverse teaching materials, especially digital materials, built from a multidisciplinary perspective (DE LA IGLESIA VILLASOL, 2018); development of creativity and digitality (DE LA IGLESIA VILLASOL, 2018); development of didactic projects based on real situations, thus developing skills that will be necessary for their professional career (DE LA IGLESIA VILLASOL, 2018); qualification for the use and production of Open Educational Resources (OER) (MISRA, 2012; BAGETTI *et al*. 2019); expansion of spaces for discussion and reflection on curriculum and strategies for Inclusive Education (DOS SANTOS, 2013).

According to the studies, the use of digital technologies in the teacher training process has been considered one of the key factors to increase the quality of their future pedagogical practices. However, some studies do not support that initial training that contemplates the use of digital technologies is enough to train teachers to integrate technologies in their practices. The study by Lopez de la Madrid and Chavez Espinoza (2013), for example, notes that more than half of the respondents who participated in an initial training for the use of

digital technologies, such as computers, the internet, and educational platforms, stated that they did not integrate them into their pedagogical practices. Given this evidence, in the next category of analysis we reflect on the digital competencies required of 21st century teachers that should be promoted during the initial teacher training process.

c) Initial teacher training with an emphasis on digital competencies

When addressing the importance of digital competencies in the teacher training process, we understand the relevance of teachers' appropriation of certain knowledge, aiming to become literate with, about, and through the media. To this end, it is important to reinforce the concept of digital competence. For Silva and Behar (2020), this is a concept that goes beyond digital literacy, involving a set of knowledge, skills, and attitudes that must be mobilized, so that the subject acts through technologies and has an understanding of the technological means in order to use information critically through different digital tools. The digital competencies in the studies investigated in this review allow us to discuss dimensions that permeate the professional, technological, and pedagogical field of initial teacher training for the use of technological resources in pedagogical practices.

According to Sanabria Rodríguez *et al*. *(*2014), it is necessary to strengthen teacher training programs in order to guide them in developing competencies, as this is a decisive factor in improving the quality of education. Within this view, teachers who develop these skills are able to build a positive self-concept about their own abilities, which positively impacts on their educational practice (SANABRIA RODRÍGUEZ *et al*. 2014).

The study by Karsenti and Lira (2011) showed that teachers who had access, in their training, to courses on how to use digital technologies in pedagogical activities were able to lead their students to use them, while, for those who did not receive this training, it became almost impossible to integrate them in their pedagogical practices. Also, according to Rohaan, Taconis and Jochems (2012), this experience in the formative process can make teachers more self-confident and have a more positive attitude toward the use of technologies, thus promoting an increase in the frequency of use, which consequently tends to enhance the teaching experience and stimulate skill development.

Based on the studies analyzed, it is possible to list some possibilities for the development of teachers' digital competencies. One of them states the importance of teaching practices for the development of digital skills during initial teacher training. In this context, the studies by Simard and Karsenti (2016) point out that the skills of teachers in training should be conducted in practice, which is a premise for the development of their digital literacy skills (SIMARDI; KARSENTI, 2016).

In line with this perspective, we point out positive experiences related to the field of study in media education, referencing practices from the use with, on and through media (SOSA DÍAZ; PALAU MARTÍN, 2018). According to the results of the analyzed experience, we identified the acquisition of digital skills in the following contexts: acquisition of analytical skills; interpretation of audiovisual messages; active and participatory learning; development and creation of digital content; useful strategies for future professional practice; collaborative work;

peer-to-peer communication; encouragement of moments for reflection, and the ability to critically analyze the use of technologies (SOSA DÍAZ; PALAU MARTÍN, 2018).

Another study analyzes the interaction with Web 2.0 and 3.0 as an alternative to the construction and production of knowledge in teacher training programs, thus enabling collaborative and cooperative learning through the experimentation of different digital resources (LLAMAS-SALGUERO; GÓMEZ, 2018).

According to Díaz (2019), professional development competencies such as: the exchange of activities, production of collaborative work, experiences in electronic journals, sharing of experiences, ideas, and opinions in virtual spaces are the least used by teachers. In contrast, Karsenti and Lira (2011), and Sanabria Rodríguez *et al*. (2014) report positive experiences related to this competency.

As for the development of skills related to digital citizenship, we only found one study identifying didactic strategies mediated by digital technologies to develop digital citizenship skills to prevent bullying and cyberbullying to teachers in training, which indicates the need for formative activities to be implemented and articulated with students' contexts and daily lives (MALDONADO, 2018).

Despite the important role that teacher training can play in developing digital skills, other environments and experiences can influence pedagogical practices. The results of the research by Llamas-Salguero and Gómez (2018) indicate that teachers who completed initial training stated that the formation of their skills and competencies in digital technologies did not occur at the university, but rather, were "the result of informal learning" that developed throughout their trajectory.

The premises indicate the integration of these perspectives can contribute to the qualification of digital competencies of teachers in training, because, in agreement with Llamas-Salguero and Gómez (2018), teachers with incomplete digital skills make insufficient use of digital technologies, and report a low level of competencies and skills regarding the instrumental use of basic technologies and lack of technological competencies in pedagogical applications (DIAZ, 2019; NAPAL FRAILE *et al*. 2018; KIHOSA, 2016).

Therefore, constantly assessing opportunities and challenges regarding the integration of digital technologies in pedagogical practices is necessary to reflect on the restructuring of existing training models. Thus, the studies selected in this category of analysis list challenges, indications, and recommendations regarding initial teacher training from this perspective.

One of the challenges is to overcome the belief that teachers' age can influence their level of familiarity with computers (CABROL; SZÉKELY, 2012), because, according to Díaz's (2019) research, this component is not absolute or linear, as not all older teachers have lower levels of training and use.

Another challenge deals with the need to generalize the inclusion of digital technologies in initial teacher training curricula (ORTEGA-SÁNCHEZ; GÓMEZ-TRIGUEROS, 2019), by redesigning existing curricula in relation to the domain of technological teaching skills (ZÁHOREC *et al*. 2018).

In addition, Pool (2013) makes suggestions to the field of study with the aim of overcoming these challenges, as follows: a) standards of initial teacher training for the use of technologies need to focus on more in-depth knowledge suitable for higher education; b) pedagogical knowledge should be developed

specifically for technology, and should therefore focus on the context, the nature of the technology, the nature of training in technology, and the nature of learning in technology; and c) appropriate teaching strategies based on learning theories suitable and modeled for teaching technology in training programs.

In a more practical perspective, some recommendations for teacher training programs are: (a) observation of other teachers in initial training; (b) analysis and reflection on their own teaching practices in order to develop appropriate teaching strategies; (c) development of micro classes, where practical teaching is organized with the aim of giving future teachers confidence, support, and feedback, thus developing pedagogical knowledge at a practical level; (d) providing opportunities to participate in problem-based projects, which offer the opportunity to work cooperatively, and thus enhance the professional development of their graduates (POOL, 2013); (e) focus on the influence of Web 2. 0 and Web 3.0, aiming to build capabilities for information management; and f) reflecting on the possibilities of didactic use of various tools and applications (LLAMAS-SALGUERO; GÓMEZ, 2018).

As an indication to the effectiveness of such recommendations, in particular the reformulation of initial teacher training curricula, the need for reflection about a common framework of digital competencies for teachers, as a reference basis for the definition of minimum requirements for the development of digital competencies of future teachers is emphasized (NAPAL FRAILE *et al*. 2018).

6. Final Considerations

We conclude that initial teacher training has been an obstacle to the use of digital technologies in pedagogical practices, and its graduates perceive a low level of technological knowledge at the instrumental and pedagogical levels, not feeling confident to use them. We point out that the lack of technological guidelines for curriculum planning and the minimum content that must be considered in a transdisciplinary sense in licensure courses is one of the obstacles to overcome for the acquisition of digital competencies in teacher training.

In addition, there is a need to articulate teaching practices with the integration of digital resources in order to promote meaningful experiences in line with the real work contexts of future teachers.

Another perspective that emerges is that previous experiences that indicate levels of digital competencies need to be valued and worked on in teacher training in order to qualify the transition from entertainment or personal use to a formal educational context that presupposes intentionality and clear learning aims. The study and the promotion of experiences with technology in formal learning contexts are supported by pedagogical mediation and create a favorable environment for reflection and problematization in such a way that the integration of digital technologies in pedagogical practices effectively adds quality.

The evidence we observed in the reported practices corroborates the understanding that, although the technological skills of teachers are more based on their personal experiences and trajectories than specifically on their training process at the university, the development of digital competencies in initial

teacher training is essential to enhance and strengthen the pedagogical, digital citizenship, and professional development spheres.

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