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Teacher's pedagogical desires in conducting their technological flow in Science Teaching

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Abstract: To investigate the teacher's pedagogical desires in conducting technological flow in Science Teaching, a teacher training extension course was planned and developed using this approach. The results show that the teacher's pedagogical desire and their Technological-Pedagogical Fluency integrate, enhance and promote the mediation of learning and meaning in Science Teaching.

Keywords: Teacher training; Digital Technologies; Science teaching.

Os desejos pedagógicos do professor na condução do seu fluir tecnológico no Ensino de Ciências

Resumo: A fim de pesquisar acerca dos desejos pedagógicos docentes na condução do fluir tecnológico no Ensino de Ciências, foi planejado e desenvolvido um curso de extensão de formação de professores com essa abordagem. Os resultados da pesquisa evidenciam que o desejo pedagógico docente e sua Fluência Tecnológico-Pedagógica integram, potencializam e promovem a mediação da aprendizagem e significação no Ensino de Ciências.

Palavras-chave: Formação de professores; Tecnologias Digitais; Ensino de Ciências.

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Los deseos pedagógicos del docente en la conducción de su flujo tecnológico en la Enseñanza de las Ciencias

Resumen: Con el objetivo de investigar los deseos pedagógicos de los docentes en la conducción del flujo tecnológico en la Enseñanza de las Ciencias, se planificó y desarrolló un curso de extensión docente con este enfoque. Los resultados de la investigación muestran que el deseo pedagógico docente y su Fluidez Tecnológico-Pedagógica integran, potencian y promueven la mediación del aprendizaje y el significado en la Enseñanza de las Ciencias.

Palabras clave: Formación docente, Tecnologías digitales, Enseñanza de las ciencias.

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1 INTRODUCTION

How can theory and practice be linked in teacher training on digital technologies in Science Education? One of the ways to answer this question was to develop research and extension in an articulated way. In this way, we linked theory to practice, thinking of practice as an experience with a digital resource or tool chosen based on each teacher's specific needs, knowledge, and pedagogical intentions. To answer the question, we chose the concrete context of each teacher's work as a starting point: with the resources and devices available that would be meaningful for the students involved. Through the research on pedagogical desires in the implementation of technological flow in Science teaching, an extension course for teacher training on digital technologies in Science Teaching was planned and developed, which allowed them to build knowledge based on theory in conjunction with the educational practice of the participants. The research and the extension course were developed as part of the Professional Master's Degree in Science Teaching at the Federal University of Pampa (UNIPAMPA).

This article presents the development and analysis of the results of the research, which raises the following research question: How do teachers' pedagogical desires lead to the flow of technology in Science Teaching? The results are presented in terms of the dimensions of Science Teaching, digital technologies, and intention with digital technologies. The article is organized with an initial presentation of Humberto Maturana's (2014) epistemology as the theoretical basis of learning and desire, followed by a summary of the experience with the pedagogical intervention - the development of the extension course. The methodology section presents the methodological path and foundation of the research and analysis, and the next section shares the results and discussion of the research, organized by the analysis of three dimensions: Science Teaching; Digital Technologies; and Intuition with Digital Technologies. We also share the collective reports generated spontaneously during the course evaluation. Next, we systematize the dimensions in three mind maps that highlight the concepts articulated in each one of them. Finally, we present our reflections.

As a result, we identified the importance of selecting and giving meaning to the content of Science Teaching so that technological resources can be defined and adapted to the needs and contexts of learning. The results show that when digital technologies are experienced from the teacher's

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pedagogical desire and through Technological-Pedagogical Fluency, they integrate, enhance and promote the mediation of learning and meaning in Science Teaching.

2 HUMBERTO MATURANA'S EPISTEMOLOGY AS A THEORETICAL FOUNDATION FOR LEARNING AND DESIRE

This research is based on the epistemology of Humberto Maturana (2014), in which learning is not something to be grasped, it is the transformation in coexistence, it is a biological phenomenon and its origin does not come from outside: it happens internally in the organization of the relationships that people build with what is around them. Based on this concept of learning, we can associate other concepts of the author: objectivity in brackets, conversations, interactions, and technology, concepts that are the basis of the theory of learning of this research.

Maturana (2014) criticizes the way we perceive the world, based on objectivity which the author calls objectivity without brackets, in other words, as if everything could be neutral and generalized. As if experiences, research, actions, and understandings of the world were identical and generic for all beings. The author then proposes the concept of objectivity between brackets, that is, that our understanding of the world does not occur in a generalized way, but rather allows us to understand that each experience, each individual, and each action has its singularity, and there is no neutrality. This concept is related to another of the author's proposals, which refers to perceiving and recognizing the other as a legitimate other, letting their unique experiences be the drivers of their processes, showing what they want and need and what they produce - where it comes from, where it goes.

Objectivity in brackets is another way of conceiving science, in which it is understood that it is possible to produce science by observing and explaining singularities without generalizing the results because what has worked in one place does not necessarily have to work in another, despite being similar. In this way, observing and explaining singularities objectively between brackets shows that "[...] there are as many realities as there are explanatory domains, all of them legitimate" (Maturana, 2014, p. 36, our translation). In other words, it means understanding that there are different realities and explanatory domains, and that the other person's reality may be different from mine, but that it is also valid, even if it is not the same or does not agree with mine, because "[...] all this has validity concerning something else" (Maturana, 2014, p. 123, our translation).

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For Maturana (2014), we need to interact and converse in order to learn. According to the author, conversations are made up of language and emotion, a human potential, they are "[...] different networks of intertwined and consensual coordination of language and emotion that we generate when we live together as human beings (Maturana, 2014, p. 141, our translation). This language and emotion is what underpins relationships and is woven into our conversations. It is through the exchange of experiences, through language and emotion, through the acceptance of the other as a legitimate other, that the transformations of our actions occur, determining and guiding the path we wish to follow. Conversation is therefore an interweaving of language and emotion. The issue of emotion underpins Maturana's (2014) epistemology and is related to various concepts and propositions made by the author. Conversation is not just language, just talking, what we say has to do with what we feel, and "how" we listen to others also has to do with what we feel, which is what transforms us, in other words, what we feel causes our explanatory domains to change.

For Maturana (2014), it is in the encounter with the other that interactions take place that trigger emotions that transform the subject; in other words, it is the interaction that transforms our experiences, our knowledge, emotions that lead to the transformation of our actions, a way of learning, because "learning is transforming oneself in a particular way through recurring interactions" (Maturana, 2014, p. 109, our translation). However, for this interaction to take place, the other must accept the other as a legitimate other in coexistence.

Emotion also underpins the technological life proposed by the author when he states that technology "can be lived as an instrument for effective intentional action, or as a value that justifies or guides a way of living in which everything is subordinated to the pleasure experienced in dealing with it" (Maturana, 2014, p. 203, our translation). In other words, it is our emotions that guide our technological life, it is our intentions that determine the choice of technologies and how to use them. Thus, if individuals themselves, according to their desires and emotions, in the domain of their actions, seek to experience digital technologies as an instrument for their action, these will lead to the gradual expansion of active skills in all domains, and in these domains, there is the existence of knowledge (Maturana, 2014). It is in this expansion of skills that the subject evolves, through its choices, desires and emotions. This evolution is defined: "[...] by what we choose to do in the face of the pleasures and fears we experience in liking or disliking what we produce through science and technology" (Maturana, 2014, p. 206, our translation).

Following this perspective of producing science according to our desires and interests, we

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chose Humberto Maturana's epistemology as the basis for this research, as it includes relevant concepts that underpin the entire investigation. In this way, this research considers the acceptance of the other as a legitimate other and their unique experiences of objectivity between brackets: of learning, of language and emotion, of interactions and the desire to experience digital technologies in their teaching actions.

3 EXPERIENCE WITH PEDAGOGICAL INTERVENTION

Through the extension project "Continuing Teacher Training: Pedagogical Desires in the Conduction of Technological Fluency in Science Teaching," we planned and developed a teacher training course: "Pedagogical Convocation as a Formative Path for Technological-Pedagogical Fluency" (Oliveira; Moura, 2022a). This course offered the construction of knowledge based on Maturana's theory (2014) and brought it into the pedagogical practice of the participants. Thus, the goal was to think about and propose training that was articulated and contextualized with the teaching of the participating teachers in terms of access to digital technologies, their pedagogical knowledge and intentions and their field of activity, the level and modality of teaching, the context and conditions of their students in terms of conceptual and technological knowledge, as well as access to and availability of digital resources. The extension activities were linked to the research carried out in this paper.

The teacher training course was published in social networks and was attended by 20 teachers from different levels and backgrounds: from early childhood education to secondary and technical education, from different cities of Rio Grande do Sul: Canela, Cruz Alta, Piratini, Gramado, Bagé, Alegrete and Dom Pedrito; as well as São Carlos, in the state of São Paulo. The course took place online in April and May 2022, taught by the first author of this research, with synchronous and asynchronous meetings.

The course sessions were organized as follows: presentation of the course and the participants; experiences with digital technologies in science teaching; digital technologies in education; possibilities for teaching science with technologies; exchange of experiences; intuitive spaces, context, and support; technology and science: choice of technology and science content; reflection and exchange of experiences on the technologies to be used; digital technologies and delivery of the final version of the projects; evaluation of the course; closing the course.

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One of the ways to plan the development of this training was to start from three spaces for determining digital technologies: space-context, space-intent, and space-support (Moura *et al*., 2020). The context-space refers to the context of the experience, the audience that will participate in the pedagogical actions, and the digital technologies and devices available and accessible to this audience. I also defined the intention-space, which is the intention of each proposal, that is, the pedagogical intention of the teacher in the pedagogical action. The support space is the technological resource that will be used to develop this mediation, chosen considering the intention space and the context space.

During the course, pedagogical actions were carried out that, through interactions, made it possible to discuss, reflect, transform, and exchange experiences. To carry out these actions in a way that met the pedagogical objective proposed in each action, the use of the WhatsApp application was of great value, since it met the purpose of the interaction, due to the simplicity of the technological language and the different modes of language (text, image and voice). As well as the Google Meet platform, which contributed to synchronous teaching and allowed teachers from different cities, even from other states, to share their experiences legitimately.

The results of the course were: the planning of 18 science teaching projects using digital technologies and the production of a digital guide. Of the 20 teachers who participated, 19 responded to the survey questionnaires and 18 submitted the final version of their projects. The projects developed by the participating teachers were aimed at students in early childhood education (36.8%), primary education (31.6%), secondary education (26.3%), technical education (5.3%), and included science content and digital technologies: Virtual games, periodic table, electricity generation, environment, experiments, digestive system, black women scientists, phases of the moon, medicinal herbs, development and care of plants, senses, environmental law, natural fermentation of yeast, human development, and mixing colors. The digital guide "Pedagogical Path for Teaching Science and Technology" (Oliveira; Moura, 2022b) is made up of materials used in the course and includes digital resources in video, audio, text, and image languages.

4 METHODOLOGY

In this investigation, the research methodology relies on the concept of scientific explanation and the criteria for scientific explanation validation proposed by Humberto Maturana (2014). For the author, a scientific explanation is a question based on a particular experience that proposes a

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transformation into another experience different from the initial one, accepted by the other, in response to the question being explained; in other words, it is an explanation of an experience in which "[...] the observer lives new experiences, asks new questions, and inevitably generates explanations incessantly and recursively if he or she has the passion to explain" (Maturana, 2014, p. 143, translated by us).

From Maturana's (2014) perspective, the observer is the researcher, and in the brackets of objectivity, the implicated observer is the researcher immersed in the research, actively participates in it, and changes oneself with it. This researcher can be in the experience or be the one who observes the experience. In this way, scientific explanations are proposed as a restructuring of an experience that is accepted by the observer as the answer to an inquiry that demands an explanation, actions that seek the continuation of existence. Explanations that need to be validated by other observers in the scientific community to become accepted and valid. The explanation of a phenomenon as a scientific explanation must be accepted by the observer and by the scientific community (community of observers).

A digital form was prepared and shared with the course participants on Google Forms (Chart 1), which was answered individually asynchronously and with the Free and Informed Consent Form..

Chart 1- Questions in the survey form.

• Did you use one (or more) new resources in your pedagogical proposal developed during the course? Which one(s)? Why did you use them?
• In your pedagogical proposal created during the course, did you give a new meaning to an already known resource? How did you do this?
• In your pedagogical proposal constructed during the course, how did you relate context-space, purpose-space, and support-space?
• In your pedagogical proposal constructed during the course, how was the digital technology chosen that was necessary for the proposed purpose?
• What science content was chosen in your pedagogical proposal?
• What was your goal in selecting this science content?
• How did the course contribute to your unique practice?

Source: Authors (2022, translated by us).

Discursive Textual Analysis (ATD) was used to analyze the responses. According to Moraes and Galiazzi (2007), ATD is a methodology for qualitative analysis of the texts produced in research,

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in this case, the answers to the questionnaire, which makes it possible to build new understandings of the phenomenon and its discourses.

The first process of ATD involved identifying the units of meaning by disassembling the texts into units related to the research question (to identify the units of meaning, we created acronyms to represent the initials of each participating teacher and numbers to separate the units - ensuring anonymity). The following process was to create categories to group the units of meaning with similar meanings. In this research, three categories were identified: the dimension of science teaching, the dimension of digital technologies, and the dimension of intention with digital technologies. The third process of ATD is the construction of the metatext, which is the stitching and articulation of these categories produced with the voices of the participating teachers, drawing a dialogue with our theoretical references. The metatext is made up of "description and interpretation, representing the whole of a way of theorizing about the phenomena under study" (Moraes; Galiazzi, 2007, p. 32, translated by us). Thus, the metatext is the union of a group of texts in which the categories are structured "which, when transformed into texts, lead to descriptions and interpretations capable of presenting new ways of understanding the phenomena studied" (Moraes; Galiazzi, 2007, p. 89, translated by us). A metatext was constructed for each of the dimensions (categories) of analysis, taking into account the discursive answers to the open questions.

5 REULTS AND DISCUSSION

This section presents the results and discussion of the research, organized by the analysis of three dimensions of science teaching, the dimension of digital technologies and the dimension of intent with digital technologies. Additionally, it includes the collective reports produced spontaneously during the course evaluation. Finally, the dimensions are systematized into three mind maps that highlight the concepts articulated in each of them.

5.1 Dimension of Science Teaching

In this section, we analyzed the responses to our questionnaire dealing with the science teaching dimension. Based on the analysis of the answers to the question: "What was your objective in choosing the science content?", the following metatext was constructed, which shows the results of

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the research on the Science Teaching Dimension. According to the teachers' answers, we constructed five categories that address the objectives of content selection: Relevance of the subject; Transformation of pedagogical practice; Understanding of the content and its process; Mediation through technology; and Construction of knowledge.

The category "relevance of the subject" shows that the criterion for choosing content for planning practice mediated by digital technologies was related to the importance that the teacher attached to this content. The following responses appeared in this category:

> LG1 My goal is for students to understand the importance of plant growth;
> JRD1 My goal was to help students understand the importance of caring for nature;
> M1 I found the topic interesting;
> ES1 To appreciate and recognize black women scientists;
> CL1 To raise awareness not only among the students, but also among the school community as a whole;
> CA1 To show the importance of using herbs;
> TF1 To make students aware of the importance of caring for the environment.
> (translated by us).

Such criteria for choosing content are related to the teacher's desires and interests so that the student realizes the importance of science:

> [...]the poetry of science is based on our desires and interests, and the course followed by science in the worlds we live in is guided by our emotions, not our reason, insofar as our desires and emotions constitute the questions we ask when we do science (Maturana, 2014, p. 157, translated by us).

Doing science and understanding it means following processes through research, observation, reflections and hypotheses. Thus, in the category “understanding the content and its process”, the following answers appear:

> L1 to reflect on the topic;
> TF2 to show that the environment is much more than plants and all that surrounds us;
> LG2 and its development;
> JAP1 to know if the phases of the moon affect life;
> CA2 medicinal uses;
> EP4 the sense of hearing;
> JM1 Knowledge of legislation;
> LF1 Teaching about living microorganisms; LF2 and their actions;
> ES1 Show my students how they were born;
> ESa2 and what they will look like;
> PO1 Exploring with students how these colors mix; PO2 Making others;
> TV1 Exploring the outside space of the school, the nature that is there; TV2 Asking the students to look; [...] TV4 The growth and development of the plant;
> AM1 To identify how children in early childhood education can build scientific understanding.
> (translated by us).

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These responses describe a way of perceiving science as part of everyday life, ideas that underpin scientific literacy, which is understood: "[...] as the ability of individuals to develop an understanding of situations in their lives that involve scientific knowledge, through processes of inquiry and the use of critical analysis" (Sasseron, 2018, p. 1066, translated by us).

These actions are important for Science Teaching because the development of scientific literacy is:

> [...]considered as a goal of science education aimed at enabling subjects to learn about the sciences, to recognize the ways in which the sciences understand phenomena, to use these ways of structuring ideas and thoughts to analyze phenomena and situations related to them, and to make their decisions (whatever they may be) in light of these contributions (Sasseron, 2018, p. 1068, translated by us).

Thus, for the students to understand and learn how to do science, it is necessary to encourage them to do research, because "[...] by doing research we get to know and by getting to know we produce meanings, knowledge, paths, explanations, understandings, concepts..." (Moura, 2015, p. 75, translated by us). In this way, the student will be constructing knowledge relating to the concepts, through reflection and understanding that show different possibilities of understanding and perceiving the same process, in other words, different ways of learning the concept studied.

> We do Science by observing, understanding, sharing, and producing knowledge; not only by validating truths and proving hypotheses, but also by legitimizing diverse voices. It is in these many actions that we can talk about Science, in the plurality and diversity of ways of doing and understanding it (Moura *et al*., 2020, p. 204, translated by us).

Such actions are possibilities that make the educator reflect on their teaching practice in Science Teaching, as we can see in the answers in the "transformation of pedagogical practice" category:

> AC2 to enable new ways of learning;
> VB1 To work with the children's curiosity;
> EP1 My aim was to do something interesting;
> EP3 so that they could learn through play.
> (translated by us).

Responses in this category show practices designed to help students learn the proposed content. According to the responses, the goal of the practices was to provide new ways of teaching so that students have a better chance of learning the content covered. In other words, teachers are trying to help students develop:

> [...]cultural practices of knowledge production,

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> somewhat similar to those found in scientific activity. Thus, by becoming subjects of these practices, students would perform mediated actions through which they could come to master certain scientific knowledge and methods (Paula, 2017, p. 81, translated by us).

Stimulating teaching through the student's curiosity, starting from the interest of those involved, and thus with the playfulness that promotes learning, means thinking about science teaching "[...] from a transformative perspective, based on dialogicity, freedom, autonomy, critical sense, decision-making, respecting the worldview of the subjects involved in the educational process" (Chagas, 2021, p. 20, translated by us). Pedagogical actions with these characteristics allow the transformation of others and of oneself through the exchange of experiences, dialogue, and reflection.

From the perspective of transformative pedagogical actions, the category of "mediation through technology" emerges. As we intended, digital technologies appeared in the dimension of science teaching, showing the coherence of the course and the teachers' perception of technological-pedagogical fluency (FTP):

> PS1 Making science teaching more enjoyable;
> EP2 using the digital medium;
> EP5 using the virtual platform in an interactive way;
> L2 using technology;
> TV3 for the details and to follow the day-to-day, photos and our filming;
> AC1 To be considered as another didactic/pedagogical tool.
> (translated by uu).

Teachers report that making pedagogical proposals mediated by digital technologies is all about changing the way science is taught. One of the ways is to propose activities in which students can see and follow all the stages and record them using technological resources. These resources allow "students themselves to carry out experiments that are crucial for understanding scientific concepts, models, and theories, while also being challenged to interpret the results of these experiments" (Paula, 2017, p. 81, translated by us). Through the possibilities of technological resources, students can learn to explore, seek answers, and generate hypotheses about the content studied, processes that are carried out interactively and more dynamically. From the teacher's point of view, he or she has the opportunity to expand his or her technological-pedagogical fluency with each planned action. PTF is something that is built up over time and "[...] is based on theoretical, practical and emancipatory knowledge" (Mallmann; Schneider, 2021, p. 1121, translated by us).

We are also aware that some teachers still think of technology only in terms of its use, which compromises the mediation potential it offers for teaching. In order to describe and deepen the

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possibilities and experiences of digital technologies in the classroom, we share the analyses related to this dimension in the following section.

5.2 Dimension of Digital Technologies

In this dimension, the teachers first answered which resources they had chosen to communicate the pedagogical proposals they had developed during the course, which were quite varied, mentioning software and platforms, equipment and spaces: YouTube, Data-Show, Resources available at school, PowerPoint, Videos, Repositories, Photos, Camcorder, Podcast, Virtual games, Quiz, Mobile phone, Jamboard, Internet, Social media, Research sites, Padllet, Notebook and Computer lab.

Regarding the question: "In your pedagogical proposal constructed during the course, did you give a new meaning to an already known resource?", 14 (fourteen) teachers gave a new meaning to an already known resource, representing 74% (seventy-four percent). The other 5 (five) responded that they didn't give new meaning, representing 26% (twenty-six percent). Regarding the teachers' descriptions of how they gave a new meaning to an already-known technological resource, we created a word cloud from their answers. This cloud shows the goal of giving a new meaning to the chosen digital technology. As shown in Figure 1, we can see that the goals are related to research, students, and recording, that is, there is a link to pedagogical intent. Other objectives are related to the use/application and the tools and resources, in other words, they are related to the technical issue.

Figure 1 - Word cloud “new meaning of chosen digital technology”.

Source: Authors (2023).

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5.3 Dimension of Intent with Digital Technologies

This metatext shows the results of the research on intention, which according to Moura *et al*. (2020) refers to the pedagogical intention of each action, that is, the purpose for which we choose and experience a particular digital technology. Teachers' pedagogical intentions appeared when they answered why they used one (or more) new resources and how the chosen technology was necessary for the proposed purpose, which defines the purpose space proposed by Moura *et al*. (2020). According to the responses, we built six categories that address the purpose of digital technologies in their pedagogical proposal, namely: Recording and monitoring; Engineering; Learning; Communication; Research; and Science.

Although we found two categories that show the separation between digital technology and the pedagogical part: Recording and Monitoring and Technique-Technology (limited and technical perception), most of the responses showed an articulation with Desire, Flow, and FTP. As we intended, the digital technologies appeared with the teacher's desire and the teacher's acumen with FTP. Thus, the connection between what was developed in the course.

In the “registration and monitoring” category, the following responses appeared:

> TV1 for recording the day through photos and videos;
> PO2 for creating new ideas like sharing photos for parents.
> (translated by us).

The teachers describe a limited choice in their pedagogical proposal, proposing digital technology only as a resource to record the activity or its development, to illustrate each stage to monitor its progress, or simply to share with the school community in a demonstrative way. Thus, we see that there is a need to develop FTP because it "[...] promotes the increment of new educational practices and generates didactic-methodological innovations" (Mallmann; Sonego, 2016, p. 148, translated by us).

In the category: "Technique-Technology", the responses describe that the objective is linked to the technique:

> AC2 making virtual games more powerful;
> PO1 for the frequent use of students in watching videos, using resources they know, bringing their reality;
> EP1 at the moment I haven't used any of these tools;
> EP2 but I've seen that they're very good for doing work, presenting etc...
> CL2 because I can use Jamboard as long as I have access to the internet and as I work in a rural area, where the internet is always fluctuating, I took advantage of this and left Paint on standby. Because it

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> doesn't require internet access.
> JM1 quiz to assess learning;
> TF2 and I liked the suggestion of including a quiz to conclude the activity;
> JM1 Expanding the proposed theme.
> (translated by us).

In this category, the responses show that teachers found it difficult to relate the importance of pedagogical articulation, to say how digital technology contributed to developing a transformative lesson, where students and teachers are authors of the process, creating and recreating through the chosen resource. They technically describe digital technology, as limited to something chosen to evaluate, present, visualize, and conclude. We perceive a disconnection between digital technology and pedagogy, thus missing the "[...] action that enhances interactivity and interaction in educational practices mediated by technologies" (Mallmann *et al*., 2013, p. 311, translated by us). In other words, it shows the need to further develop their technological-pedagogical fluency to implement a pedagogical proposal mediated by digital technology. This situation is different from the following categories, where we perceive that most of the units of meaning correspond to what was proposed during the course, showing articulation with the teacher's desire, technological fluency, and FTP.

In the "learning" category, the responses show an articulation between the intention of what had been proposed and the search for pedagogical transformation, describing the potential and possibilities of teaching mediated by digital technology. Also, the technological-pedagogical fluency of the teachers and their desire, as can be seen in the following answers:

> PS1 To integrate students with each other and with technology, and for students to feel and learn science through technology.
> PS2 Because I was able to reach all levels of learning through the use of these technologies.
> AC1 To empower students to be leaders;
> AC2 To show students that we can enhance our learning through new technologies;
> CA1, so that learning could take place in a practical way.
> JRD2 to record every moment of learning and the students' reactions.
> JRD2 to make learning easier to understand.
> (translated by us).

Teachers emphasize the intention, the desire, the emotion in the action of building their science teaching proposals because the "[...] fundamental emotion that specifies the field of action in which science as a human activity takes place is curiosity, in the form of the desire or passion to explain" (Maturana, 2014, p. 142, translated by us). We noticed an interest in monitoring students' progress along the way, and teachers described how digital technology allowed them to enhance their teaching and the role of their students. In these units of meaning, we can see that the teachers have a certain technological-pedagogical fluency, as they are teachers who

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have carried out different actions "[...] for whom knowledge about technology and how to integrate it into pedagogy is a constant need when thinking about technological resources as enhancers of the teaching-learning process" (Schneider; Schraiber; Mallmann, 2020, p. 1988, translated by us).

This pedagogical perspective includes the category "communication" because to transform the learning process, it is necessary to communicate what has been learned. In this category, teachers responded:

> EP1 using communication, and networks through the course;
> EP2 to help communication in the school environment.
> (translated by us).

The answers show the concern and the intention to communicate as a way of sharing ideas, not only with those involved in the action but also with other people, in other words, to share the knowledge and the way of teaching that were part of the pedagogical proposal. In this way, other teachers will have the: "[...] the possibility to interactively create, modify, explore and adapt these resources, sharing new concepts, functions, programs and ideas" (Schneider, 2017, p. 50, translated by us), adapting them to their context, according to their needs and pedagogical intentions.

In the category "research" we can see the intention as a way of learning through research, defined as "[...] a rational and systematic procedure that aims to provide answers to the problems proposed" (Gil, 2009, p. 17, translated by us). The following responses appeared in this category:

> PS1 for research;
> TF1 I used a research proposal;
> ESo1 To carry out research in class.
> (translated by us).

These intentions demonstrate a pedagogical proposal in which the student is an active agent who, through research, seeks answers, creates hypotheses, reflects, understands, explains, and compares situations to arrive at possible explanations, possibilities, and paths to knowledge.

The last category "science" includes the intention of what we want to teach, considering science as "[...] a domain of action, and as such it is a network of conversations that involve affirmations and explanations validated by the criterion of validation of scientific explanations under the passion to explain" (Maturana, 2014, p. 141, translated by us). This category had the following responses:

> ESo1 To know and appreciate the black women who are part of our history in technology;
> ESa1 The video was necessary to show human development from baby to adult;

PO1 Relate the use of technology to explore the mixing of colors, taking into account the students' prior knowledge;
LG2 Allow students to follow the growth of the plant;
M1 Use different ways of teaching the periodic table;
CL1 To stimulate students' interest and use technology to learn science;
TV2 because no matter how much the class follows the plant every day, we can't keep track in our brains of how it was each day and what its total development was at the end of the month. But through the photos, it is possible to make these comparisons and better understand the differences.
(translated by us).

The responses describe the intentions regarding science education and content diversity concerning the desire to teach and also to activities mediated by digital technologies as learning opportunities. The pedagogical intentions include why the activity must be mediated by digital technology, how this choice contributes, and its importance in relation to pedagogy and science teaching. These approaches have been considered and pursued in the development of the course, which demonstrates their coherence.

5.4 Collective speeches about the course

The teachers, despite the diversity of training, level and area of activity, answered the question: "What does this training contribute to your unique practice?". The answers were systematized and grouped together in Chart 2 as a collective discourse of the teachers.

Chart 2 - Speech by the collective of teachers about the contribution of the course to their practice.

The course was very interesting! It brought new learning, and new knowledge and improved our view of things that matter, with an exchange of information that contributed to the whole, to everything, because it valued each context and helped with adaptations all the time. It was great to interact with colleagues from different places and different realities. I realized that I'm not alone in my concerns. It contributed positively and reflectively, showing that it's important to always update practices by applying science education to everyone's daily life. I've learned a lot about technology, how to use it better, how to make it easier, and how to rethink how to use these resources more in the classroom, not just with YouTube videos, lots of apps that I didn't know about but that are super cool and that I recommend! I've expanded my knowledge of digital technologies since previous courses, and I know that we're always picking up new knowledge that adds to our teaching practice. Even though I don't work in the classroom, the course has given me new challenges and a lot of learning that I will use both to study and to teach one day! It has been an extremely significant personal breakthrough, it has given me many personal achievements in terms of freedom of expression, and I have been able to change some practices. It unearthed something that had been forgotten: the possibilities and richness of using digital technologies for teaching, and I was able to reflect on my practices and actions, showing the importance of using technologies.

Source: Authors (2023 translated by us).

At the end of the course, teachers had the opportunity to make comments, suggestions and criticisms on a bulletin board, using this space to thank, praise and congratulate, describing how

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important the course was for learning.

Chart 3 - Speech by the collective of teachers on the bulletin board.

In this course, I found reasons and technologies that made me want to further my qualifications as a teacher. It allowed me to learn about tools I didn't know before and challenged us to think about digital technologies as a mediating and transforming resource that is part of the educational process. Activities that stimulated further reflection on teaching practice and encouraged us to face the challenges posed by digital technology. Overcoming technological difficulties, opening horizons in the immensity of learning/knowing. Maintaining this course format, the enthusiasm, commitment, and effort to make good courses, good classes, sharing and transforming [...] careers. The classes allowed us to interact and talk, and even when it wasn't possible to participate, we were encouraged to watch the recordings to find out what was said. The activities were fun, and clear, made it easy to understand the objective, and consisted of educational content, with constant encouragement and willingness to answer any questions.

Source: Authors (2023, translated by us).

As can be seen in Chart 3, one point to highlight was the commitment of the teachers to the development of the course and the activities. Whenever they couldn't attend the synchronous meetings or were late with the asynchronous activities, they gave reasons before and after the meeting and handed in all the activities. They also said that when they watched the recording of the meeting, they followed what was done. These attitudes show that they considered all the stages of the course important for their training and that the commitment of the teachers made it possible to successfully achieve the objectives proposed in the course and the research. Other indicators of the contributions of the course were the analyses carried out by the teachers using the online forms, based on the dimensions of science teaching, digital technologies, and intuition with digital technologies.

5.5 Mental maps

To summarize the analyses of each dimension, mind maps of the main approaches were created (Figures 2 to 4). The words were selected by the researchers after reading the teachers' responses and identified as keywords. These words were placed randomly on the mind maps (i.e., they do not show any hierarchy or order) just to give a summary picture of each of the dimensions.

Figure 2 highlights that in the analysis of the science teaching dimension, teachers showed concern about the choice of content, and the importance of the content for the teacher because we do science through questions generated by emotions and desires (Maturana, 2014). And to understand the content and the process, it is necessary to research and produce science, so that scientific literacy

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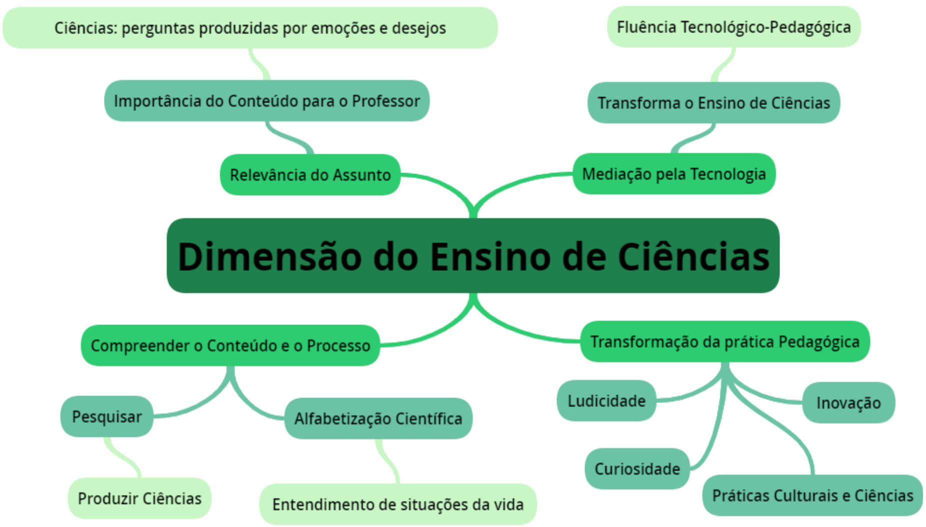
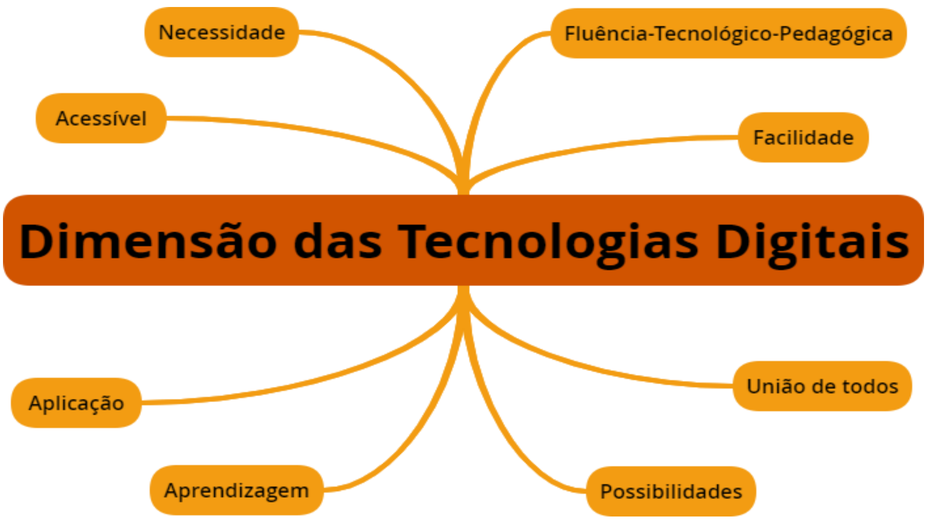
occurs and the understanding of life situations that science education considers. In this way, pedagogical practice is transformed to include innovation, playfulness, curiosity, cultural practices, and science. In this dimension, it also appears that actions mediated by digital technologies transform the teacher, and their teaching practice and promote more technological-pedagogical fluency, essential elements in the teaching and learning process of science teaching.

Figure 2 - Science Teaching Dimension Mind Map.



Source: Authors (2023).

Figure 3 - Mendtal Map of the Dimension of Digital Technologies.



Source: Authors (2023).

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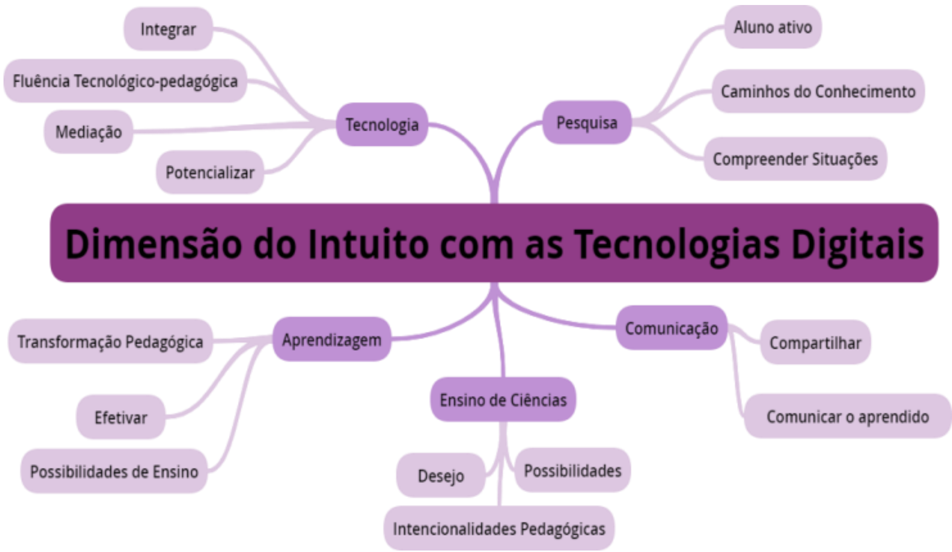
In the analysis of the digital technologies dimension (Figure 3), teachers challenged themselves to choose new resources to convey their pedagogical proposals, adapting them to their needs and contexts. In this way, they selected different resources to learn about them, to get to know their applications and possibilities, or to give them a new meaning so that they could easily use them, according to their pedagogical intentions and technological-pedagogical fluency. The concepts proposed in the course "Space-context, Space-intent and Space-support" (Moura *et al*., 2020) helped to make this choice more coherent because they selected the resources (Space-support) according to their space-context and space-intent.

Figure 4 summarizes the dimension of intention with digital technologies, showing that teachers considered digital technologies as a way to integrate, improve, and mediate teaching, according to the intention of their pedagogical proposals in science teaching, with greater technological-pedagogical fluency. In this dimension, research appears as a path to knowledge and understanding of the situations studied, which allows students to be active agents in their learning process. It also involves communicating what has been learned and sharing ideas so that learning is effective, showing different teaching possibilities, and promoting pedagogical transformation.

Figure 4 - Mental Map of the Dimension of Intent with Digital Technologies.



Source: Authors (2023).

The three dimensions were science teaching, technological-pedagogical fluency, digital technologies, and a pedagogical approach or perspective in line with the articulations proposed in the course as a pedagogical intervention proposal and the research question. In this way, the goal of the teachers' pedagogical proposals in science teaching came

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from their desire, their possibilities, and their pedagogical intentions. Thus, this research and the pedagogical intervention can be a reference for other researchers, not as a ready-made recipe, but as a study in which the teacher learns to learn, to reflect, and to make inquiries about the knowledge and the contributions of digital technologies to their training, thus modifying their teaching practice and looking for strategies that transform contexts and people.

6 CONSIDERATIONS

The development of this research allows us to answer the research problem and to affirm that teachers' pedagogical desires drive the technological flow in science teaching through their choices, pedagogical intentions, and desire to transform themselves as teachers and also their teaching practice, thus providing their students with different ways of learning the content. We positively evaluated the interactions of the participating teachers during the pedagogical intervention, and their commitment to the proposed activities, because even if they could not attend a meeting, they tried to find out about the topic or the proposed activity and carry it out, even if they were late, a fact that shows how committed the teachers were to their training and that of their colleagues. The exchange of experiences among the course participants and the use of theoretical and practical tools led to further learning and improvement of previous knowledge.

When thinking about and proposing teacher training in digital technologies, the aim is not to update or train them in all the resources and media available, nor to promote all the applications. The focus was on creating spaces and interactions that allowed teachers to experiment and discuss digital technologies and to understand how pedagogical intentions guide and determine their practices.

Based on the results, we found that the teachers in the professional development course understand the connections and contributions of digital technologies in science education as a possibility to expand the ways of teaching and learning according to their desires and pedagogical intentions. The participants are aware that there are different ways of approaching the same content and that to do so, it is necessary to know to plan according to their context, theme, materials, intentions, and digital technologies that enable quality learning for their students.

Finally, the course and the digital guide can be easily adapted for other groups of teachers. Thus, these educational products provide teachers and educational institutions interested in theoretical and practical material that will serve as a reference for teacher

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training with digital technologies in science education. The results of the research show the importance of selecting and giving meaning to the content of science education to define and adapt technological resources to learning needs and contexts. The results also show that when digital technologies are experienced from the teacher's pedagogical desire and through technological-pedagogical fluency, they integrate, enhance and promote the mediation of learning and meaning in science teaching. In this way, we can see the importance of the connection between technology and pedagogical practice. However, for this to happen, students and educators must have technological pedagogical fluency as well as digital technology resources.

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