Essential knowledge for professional education teachers

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Abstract

The research investigated how digital technologies are integrated into pedagogical practices based on the TPACK model. A systematic literature review and interviews with teachers were carried out, with automated content analysis using the Iramuteq software. The results indicated that curation is the way in which teachers integrate digital technologies into pedagogical practice. Difficulties were identified in the curatorship process and the training of teachers by levels of technological knowledge was proposed, with a virtual learning environment as an educational product.

Keywords: teacher training; digital technologies; technological pedagogical and content knowledge (TPACK); curation.

Introduction

Society is experiencing major technological advances, and education appropriates these changes by including digital information and communication technologies (TDIC) in its teaching and learning process. In this context, Kenski (2007, p. 18) states that education has a double challenge: "adapting to advances in technology and guiding everyone towards mastery and critical appropriation of these new media". Thus, there has been a cascade of digital technologies that have changed the labor market.

Technical professional education (EPT) has been adapting to this new scenario, since its focus is on educating for work. The technological and pedagogical work of teachers in technical professional education, however, points to the lack of such knowledge in their professional practice, also in remote or hybrid classes, a new phenomenon in our reality (KENSKI, 2012).

There is, therefore, a need for new professional courses to train teachers for this new teaching profile whose goal is to teach using the TDIC. Moreover, the majority of EPT teaches have no pedagogical training, as they are valued for their professional experience and mastery of the content (CORDÃO; MORAES, 2020). According to Masetto (2000, p. 138), "this new technology provokes debate about its use, as well as the role of the teacher and their pedagogical mediation [...]".

How do the technical professional education teachers integrate digital information and communication technologies into their pedagogical practice?

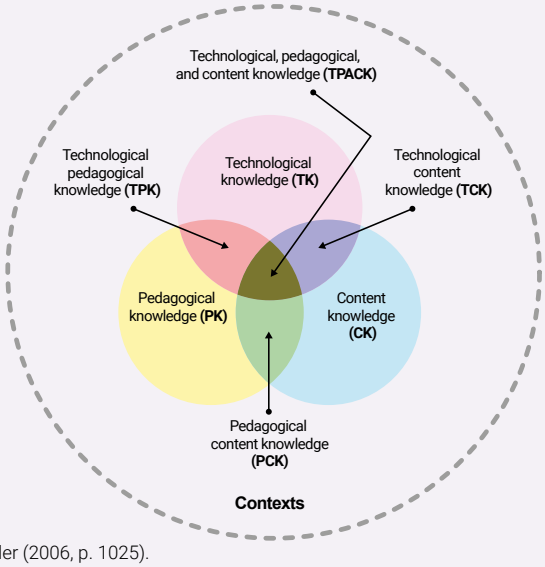
Thus, this research raises the following problem: how do the technical professional education teachers integrate digital information and communication technologies into their pedagogical practice?

To answer this question, the general objective was defined, which aims to investigate how digital technologies are integrated into pedagogical practices based on the theory of technological pedagogical content knowledge. The specific objectives are: a) identifying the digital technologies used in teachers' practices; b) identifying the difficulties faced in using the TDIC; c) analyzing how teachers incorporate the use of digital technologies into their professional development; d) proposing continuing training for EPT teachers.

The research was based on the theoretical framework called technological pedagogical content knowledge (TPACK), by the authors Mishra and Koehler (2006), who point out for the existence of the need for teachers to develop technological knowledge integrated with pedagogical content knowledge (SHULMAN, 1986) in the process of didactic transposition (PAIS, 2010) and pedagogical mediation (TÉBAR, 2011).

The concept of the theory is represented by the Venn diagram, a graphical form represented by three overlapping circles, which includes three types of teaching knowledge needed by a teacher in the teaching and learning process: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK), as shown in Figure 1.

Figure 1. Components of TPACK



Source: Mishra and Koehler (2006, p. 1025).

According to Mishra and Koehler (2006), the integration of the three types of knowledge results in another four: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge

(TPK), and, finally, the *Technological Pedagogical and Content Knowledge* (TPACK), the result of the intersection of all elements. Moreover, the authors emphasize that the articulation of all these types of knowledge is limited to the educational context in which the teacher works.

This research is justified by the significant increase in digital technologies in the educational environment, which, according to Kenski (2012), shows how technology and pedagogy are inseparable for the transposition of content, making both fundamental for teacher training to improve the teaching and learning process.

Methodological path

The methodological path consisted of a systematic literature review and an exploratory, descriptive-analytical study with a qualitative-quantitative approach. In reviewing the existing literature on the development of the TPACK model, it was only considered studies in the Portuguese-speaking context, published nationally and in the period between 2015 and the first semester of 2020, to verify the perspectives and challenges of this pedagogical proposal (FURTADO; OLIVEIRA; PAREDE; BRITO, 2021).

Secondly, in the qualitative-quantitative research, a semi-structured interview with semi-open questions was used as a data collection tool, which were analyzed using the technique called automated content analysis, derived from content analysis, incorporating technological possibilities in the data processing, aided by the software Iramuteq (GRIMMER; STEWART, 2013). The research was carried out at a private technical professional education institution in the city of Guarulhos, in the State of São Paulo. Teachers were selected for convenience, as the sources were selected for their proximity and/or availability. Five teachers were invited from the following areas: management and business, logistics, well-being and social development, considering that they all use TDIC in face-to-face or remote classes, but with different levels of mastery, based on the researcher's perception. After the initial contact, the participating teachers were presented with the objectives of the research and asked to sign the Informed Consent Form.

Due to the social isolation caused by the Sars-CoV-2 virus pandemic, the interviews were scheduled at pre-established times, according to the availability of the teachers, and carried out via videoconference on the Microsoft Teams program, respecting the characteristics of the research. With the participants' consent, the interviews were recorded so that the audio could then be transcribed. For the automated content analysis, we used the software Iramuteq (Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires), version 0.7 Alpha 2 (http://www.iramuteq.org/). This is an open source software that uses R as its statistical language (RATINAUD, 2009).

Once the participants' answers were collected, the monothematic textual *corpus*[1] was prepared for analysis of the results. The anonymity of the research participants was preserved, so that there is no nominal description or any other means of

identification. Once the *corpus* had been prepared, the results were analyzed using word clouds, descending hierarchical classification (DHC), Reinert's method, and factorial correspondence analysis (FCA).

A word cloud is a visual representation, a graph or infographic, in which each word is represented with a size proportional to the frequency in which it appears in the text or dataset. To generate the cloud, the number of times each word appears in the text is identified and artistically distributed.

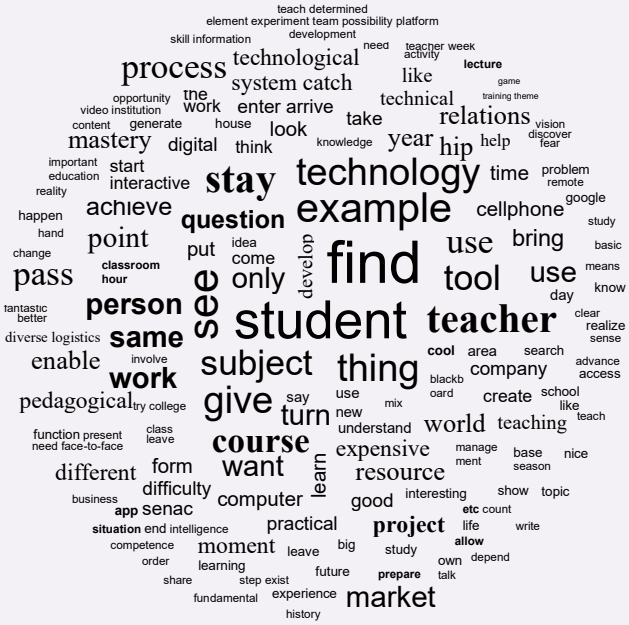
The algorithm created by Reinert generates clusters of lexical categories, without interpretation or prior interference from the researcher. From the generated clusters, it was possible to categorize the text by descending hierarchical classification, as well as by factorial correspondence analysis. The significance of the clustering was identified by a statistical test based on the frequency of citations using the chi-square calculation. The value tabulated by the Reinert method for this test is 3.8, with a statistically significant level of probability corresponding to a value of $p < 0.05$.

Results and discussion

The use of digital technologies in technical professional education

Analyzing the most frequent words in Figure 2, it can be inferred that the teachers described that the "student" must "find", in the sense of giving an opinion, which digital "technologies", "tools" are suitable for use in "class" (pedagogical practice), through "examples" mediated by the "teacher".

Figure 2. Word cloud results



Source: Iramuteq.

Given this interpretation, Weisz (2018) explains that teachers must understand how students learn and, based on this, they must design activities as to allow students to develop, i.e. teachers must observe, listen, and understand which digital technologies are more accessible and suitable for student learning in class. There is also a need for teachers, as subjects in the teaching process, to be responsible for mediating and guiding the use of these digital technologies through examples.

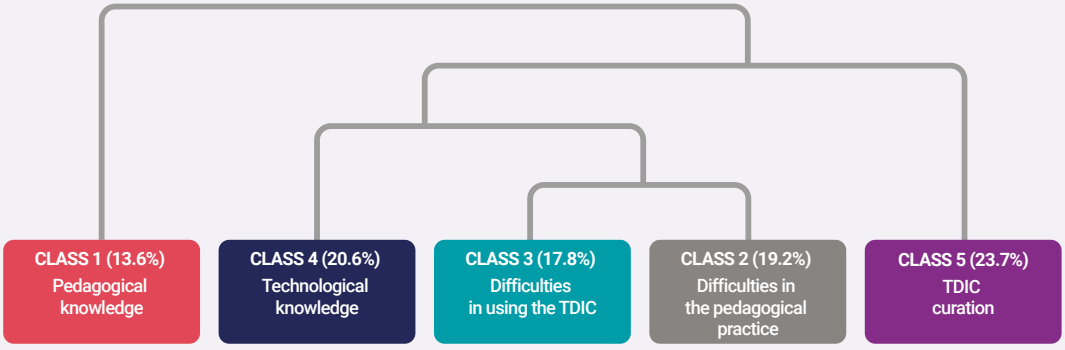
Another possible interpretation from the word cloud (Figure 2) is an exchange relationship between teacher-student and student-teacher, who are searching (find) for the construction of knowledge. To this end, Masetto (2000) states that teachers must be facilitators and motivators of learning, using dialogue and exchanging experiences with students in the search for solutions to problems (knowledge). In this sense, it is worth noting that meaningful and transformative learning, according to Rogers (1992), takes place in a classroom environment that is welcoming, collaborative, and of trust between the people involved in the teaching and learning process.

The curator teacher of the content pedagogical technology

As a result of the automated content analysis, the quality of the corpus was considered adequate, as it was over 70% used, as indicated by Reinert's method, already described in the research methodology. The corpus was separated into 922 text segments (ST) based on the answers, with 751 ST (81.45%) being used. There was 34,446 occurrences (words, forms, or words), there being 2,148 active forms (different words) and 263 were supplementary forms, making up a single set.

The content analyzed was categorized into five classes (clusters), based on the descending hierarchical classification (DHC), obtained using the Reinert's method. The distributions of text segments are presented in dendrogram format – a tree diagram that displays the groups formed (classes) in their levels of similarity, based on the characteristic vocabulary (lexicon), as shown in Figure 3.

Figure 3. Descending hierarchical classes



Source: Iramuteq.

Figure 3 shows that five classes were generated by the automated content analysis, divided into two branches of the total *corpus* of analysis, also called subcorpus. Thus, two subcorpus are identified: A and B; in subcorpus A, from left to right, only Class 1 (red) was obtained, isolated from the others due to its specificities, which differ from subcorpus B, containing Classes 2, 3, 4, and 5. In subcorpus B, Class 5 (purple) was obtained at first, the only one that is directly related to Class 1 in subcorpus A. Then, Class 4 (blue) was obtained for subcorpus B and, in a third moment, Class 2 (gray) and Class 3 (green). The name and interpretation of the results for each class are presented below.

The importance of pedagogical knowledge in the use of digital technologies

Class 1, herein called "pedagogical knowledge" – due to the characteristics that stood out the most from the lexical analysis – refers to teachers' pedagogical practice. According to Mishra and Koehler (2006), pedagogical knowledge is one of the three types of knowledge in the TPACK model necessary for pedagogical practice.

In the statistical analysis of the chi-square test (X^2) of the words and the context in which they are inserted, pedagogical knowledge is essential for pedagogical practice aimed at student learning. A teacher "with deep pedagogical knowledge understands how students build knowledge, acquire skills, and develop habits of mind and a positive disposition towards learning" (MISHRA; KOEHLER, 2006, p. 1027).

This movement, however, requires the teacher to adopt an attitude of a researcher, in the search of new competencies and skills, in order to improve their pedagogical practice, as it can be seen in the P1-A's reports. The highlighted words (bold) were decoded by the software and appear more frequently in Class 1. The reference P plus the number identifies the teacher interviewed, and the letter that appears next establishes the order of each teacher's reports.

> [...] the teacher should adopt a profile of a researcher, he has to be that person who is always seeking to develop new things or new procedures, new processes, new learning situations, and who sees technology as something that facilitates or something that is used in the market (P1-A).

From this perspective, Tebar (2011) and Masetto (2000) state that teachers must improve their pedagogical methods and strategies in order to act as a mediator and facilitator of learning, as well as understanding how students build knowledge (learning).

Regarding teacher P1-B's report, it is stated that pedagogical foundations are essential for the development of competencies and skills in students. According to Pais (2010), one of the pedagogical foundations is didactics, the field of study of the teacher's teaching knowledge, which consists of didactic transposition techniques that aim to transform scientific/technical knowledge into teachable knowledge, so that the student can easily understand and apply it. "Pedagogical practice is when we have a competence, a technical skill that we need to develop in the

The teacher is a mediator, who leads people to use their skills, discover their potential, and improve their competencies

student, throughout a course, and we are going to use pedagogical foundations to be able to make this transposition" (P1-B).

According to Tébar (2011), pedagogical mediation aims to lead students to develop their potential and skills through a pedagogical process based on a deep awareness of the teacher regarding the pedagogical assumptions involved in teaching and learning. For example: institutional pedagogical proposal, active methodologies, formative assessment, knowledge of how the student learns and understanding of the didactic gestures necessary for the didactic transposition of scientific knowledge into learned knowledge, as reported by teacher P1-C: "The teacher is a mediator, who leads people to use their skills, discover their potential, and improve their competencies, this is my understanding (how) of this figure of the pedagogical process."

In this sense, Feuerstein, Feuerstein and Falik (2014), as well as Franco (2012), observe that pedagogical practice is intentional and planned, rather than a reproduced teaching practice, without reflection and purpose. According to Roldão (2007, p. 101), the professional teacher "is one who teaches not only because they know, but because they know how to teach".

Thus, the content of pedagogical mediation cannot be disregarded. Shulman (1986) states that the technical-scientific mastery of the subject to be taught is relevant for the application of the pedagogical knowledge, which he calls pedagogical content knowledge, the basic concept for Mishra and Koehler's TPACK model (2006).

Teacher P3-A's report highlights the importance of this relationship between content and pedagogy, which, according to Pais (2010), can be called didactic transposition. It is a process of transposing scientific knowledge into learned knowledge, taking into account the student's prior knowledge. Moreover, this should be enabled through a teaching methodology based on a pedagogical proposal. "The knowledge that the students already have, together with the content that I have to teach in such a way that it is enjoyable, in other words, pedagogical practice is bringing content properly and through a process" (P3-A).

With regard to P1-D's comment, it can be said that teaching is not transmitting content, but an act of pedagogical mediation that provokes changes in the student's life. In other words, "the teacher's actions should provide opportunities for the development of all forms of intelligence and empower the student according to their capacities" (TÉBAR, 2011, p. 114).

"We have to have this perception of not only training a person with technical-scientific mastery, but who also has skills and attitudes, a critical perspective", says P1-D.

Nascimento (2011) corroborates this by stating that this pedagogical practice comprises founding and specific gestures that serve to awaken the potential of students in class. The founding didactic gestures are related to the planning process

of class activities, usually based on a pedagogical proposal, while the specific didactic gestures are related to verbal and non-verbal communication between teacher and student, as well as mediation resources.

In teacher P1-E's report, the importance of the teacher conducting the class is evident, with a view to developing autonomy and a critical perspective of reality: "The student must develop reflection and learn autonomously, so when we talk about pedagogical practice, I understand that it is a mix of everything, in fact, it is how you conduct your classes."

Therefore, pedagogical knowledge (MISHRA; KOEHLER, 2006) becomes essential for teachers of technical professional education, despite not being a priority for some EPT teachers, as they believe that mastering content from the job market is enough.

The curation of digital educational technologies

According to the statistical analysis of the chi-square test (X^2), Class 5 had the highest lexical relevance among the classes. Considering the words analyzed and the context, it can be interpreted that the use of digital technologies (tools) – Google Forms and Canva – generates motivation and interaction in classes (creation, ideas, projects). It can be seen, in teacher P5-A's report, that the use of digital technology should not only be related to the subject of the class, but also promote engagement, considering the possibility of relating it to the student's professional area, as it is inserted in the universe of technical professional education. The highlighted words (bold) were decoded by the software and appear more frequently in Class 5. "Regarding a given theme, I use a technological tool that will encourage student engagement and enable the application in the business world" (P5-01).

As to the reports of teachers P5-B and P5-C, the importance of criticality in the choice of TDIC is evident, so as to enable interaction (person-person) and interactivity (person-knowledge) of the student, providing enjoyable learning (MALLMANN; SCHNEIDER; MAZZARDO, 2013), as well as arousing curiosity and the desire to learn.

"Tools that enable students to bring content to life in an interactive and enjoyable way" (p5-b). Thus, "the digital tool should generate in the student a curiosity, a restlessness, an awakening to that desire to learn through that technological tool" (P5-C).

According to Costa (2019), this assessment and selection of educational digital technology should be aligned with the learning objectives (pedagogical intent), and the choice should be for a technology that is intuitive and easy to use by the student, in order to favor the effectiveness of the pedagogical strategy and provide interactivity and student-student and teacher-student engagement. This concern can be seen in teacher P5-d's report: "I like to use Google Forms, I like to research new tools that are dynamic and interactive."

Feuerstein, Feuerstein and Falik (2014) state that intent and reciprocity – that is, the teacher's understanding of what is to be achieved and the recognition of the student as an active subject in the teaching and learning process – are universal parameters of mediation in the use of digital technologies, as reported by teachers P5-E and P5-F.

"When I am using a tool, I ask what is my purpose, so that it is not use for use's sake" (P5-E). And yet, "[...] I come back to that issue of universality, some tools you cannot use because they are heavy and sometimes the student does not have a cellphone suitable for downloading" (P5-F).

From this perspective, it can be seen, from Figure 3 (DHC), that Class 5 (purple), belonging to subcorpus B is the only one with a direct link to Class 1 (red) – pedagogical knowledge, from subcorpus A. It is evident, therefore, that the use of a digital technology should be linked to the teacher's pedagogical knowledge, i.e. an understanding of how a given technology contributes to the teacher's pedagogical mediation (pedagogical practice).

Student's context is an important aspect in the use of the TDIC in classes

Mallmann, Schneider and Mazzardo (2014) call this relationship as technological-pedagogical fluency (TPF), which we can relate to technological-pedagogical knowledge (MISHRA; KOEHLER, 2006) – the teacher's continuous process of exploring and associating technological resources with the pedagogical methods and strategies involved in the teaching and learning process.

Another important aspect, according teacher P5-G's report, is that the teacher should encourage students to use digital technologies when developing and presenting the activities proposed by him. According to Feuerstein, Feuerstein and Falik (2014), this teaching attitude of stimulating curiosity is called transcendence, since the use of technology extends beyond the immediate need.

"I present the technological resource aimed at arousing the student's curiosity about that tool and the desire to use it in the construction of knowledge" (P5-G). "I created a personal webstore on Canva and presented it to the class, without asking anything from anyone, and the students wanted to use the tool to build their project" (P5-H).

Regarding the example of teacher P5-H, Cibotto (2015) states that the student's context is an important aspect in the use of the TDIC in classes, since many students do not have the basic technological knowledge to handle the tools. Thus, the teacher must know the resource very well and present it to the students in a way that arouses their interest.

At the same time, Harris, Mishra and Koehler (2009) comment on the importance of the teachers' perception of the characteristics that justify the use of digital technology as a didactic-pedagogical resource. The aim of this perception is to spontaneously direct students along a path that will facilitate learning.

In teacher P5-I's report, it is possible to identify another universal parameter of Feuerstein, Feuerstein and Falik's (2014) mediation, which is meaning. For the authors, the teacher must provide the student with means and paths to apply the content in life.

"These digital tools should be applied in cross-curricular teaching, in which the student is made aware that such tool, for example Canva, can be used in life" (P5-I).

Finally, from the interviews, we identified some of the TDIC used in the teachers' pedagogical practice, which can be divided into two groups: (1) pedagogical mediation technology, which facilitates didactic transposition and the construction of knowledge – e.g. Padlet, Mentimeter, Canva, Jamboard, PowerPoint, Word, Excel, and Wordwall; (2) specific technologies, i.e. those aimed at the teaching and learning process, such as Comex, for exporting goods, Excel formulas, and programming languages.

The technological knowledge of teachers

According to the TPACK theoretical model (KOEHLER; MISHRA, 2006), this knowledge is different from the technical and specific domain that involves informatics and computer science, although necessary. It is about being able to use (know-how) digital technologies as a resource in the teaching and learning process.

The statistical analysis of the chi-square test (X^2) for Class 4 indicated that the technological knowledge of teachers has become essential for their teaching performance. Koehler and Mishra (2006) state that it is not possible to correctly define which technologies should be mastered for pedagogical practice, since technological changes are constant; however, the central issue is how the teacher reacts and deals with all these changes. Harris, Mishra and Koehler (2009) suggest that teachers need to adapt to this new reality and incorporate digital technologies into their teaching practice.

The following reports show that technological mastery contributes significantly to the development of classes, facilitating student learning and motivating students to take part in activities. The highlighted words (bold) were decoded by the *software* and appear more frequently in Class 4.

"My curiosity and what I have learned in computer engineering makes me want to insert everything in my classes" (P2-A). And again: "[...] I put a 3D heart beating on the blackboard and the students were thrilled" (p2-b). Another point to be highlighted was the use of the "*smart* digital blackboard, it provides us with a variety of tools, so I can do different activities in 3D and with movement" (P2-C). "Another issue is motivation, as when you conduct a class that you have prepared, it is more fruitful for the students, they are extremely happy to say that they have succeeded" (P2-D).

According to the reports by teachers P2-E, P2-F, P2-G and P2-H, technological mastery is acquired at the teachers' initiative, who aims to overcome their limitations in the use of technology (computer) by studying and testing the possibilities of using it in class. Schon (2000) comments that teachers need to reflect on their practice, i.e. it is not enough to master the technologies, they need to relate it to pedagogy and the content to be taught, further considering the social context in which they are inserted (KOEHLER; MISHRA, 2006).

Thus, we can think of "wanting to continue using technological resources and tools, and my training is what allows me to have this mastery" (P2-E). "[...] to learn something, you have to work with it" (P2-F). "I started studying distributed systems and this opened up a whole range of game possibilities for the class" (P2-G). And yet, "I see exactly this issue, the teacher has to create a habit of practicing constantly in order to acquire (this) mastery" (P2-H).

In this sense, it can be seen, in teacher P2-I's report, that teachers with a greater technological mastery tend to share this knowledge with their peers, since teaching knowledge is produced at school through the exchange of experiences and the relationship between the individual and the collective (TARDIF, 2014).

"At the beginning of the remote classes, I taught more to the teachers than to the students, the teachers constantly needed help to access the digital technologies" (P2-I).

Another factor to be considered in the educational context is knowing the socio-economic profile of the students and the culture

The educational context must be considered for the technological development of the teacher and the student, as reported by teacher P2-J. The authors Harris, Mishra and Koehler (2009) state that the school's physical and organizational structure influences teacher training and planning. Thus, the greater the institutional support for the use of educational technologies, the greater the development of the technological knowledge of the teachers. "We are lucky to be in an institution that invests heavily in technology, as well as having a building that is set up to access the internet" (P2-J).

Another factor to be considered in the educational context is knowing the socio-economic profile of the students and the culture of the local community (HARRIS; MISHRA; KOEHLER, 2009). In the following reports described in this research, it is evident the importance of the social context. Thus, the teacher must know how the TDIC works on cellphones and make sure that everyone has the same learning conditions.

"Most of our students use cellphones, but do not have a computer at home, so we have to convert it so that it works for everyone" (P2-K). For example, "the reality of my students did not allow me to open the computer and project my Excel screen and make a spreadsheet, because the students are watching the class on their cellphones. This diagnosis determines the degree of technology that should be used in class" (P1-A).

The ability of teachers to adapt to advances in technology has a direct impact on their technological knowledge. If the way of teaching changes, the ways in which people learn will also change. Considering the presence of the TDIC in education, teachers cannot teach today as they did a few years ago. Mishra and Koehler (2006) state that this new teaching competence consists of identifying the TDIC that provides new experiences for teaching and learning content. In other words, teachers must "change the way the subject can be taught through the application of technology" (KOEHLER; MISHRA, 2006, p. 1028). The following reports show the importance of this adaptation.

"In the past, you had someone who was a receptionist or a janitor who sat on a stool answering questions, but today, that person has to be computer literate and know how to take pictures and store them" (P3-A).

"The invoices were written, and they had to write all the invoices for the product that came in and went out. One day she went to work and on her desk there was a computer and an Excel spreadsheet open" (P2-L).

"We have surgery simulators, doctors are on a virtual table training, which would be impossible to do with real human beings" (P2-M).

"Today you can, by pressing a button, translate everything into Portuguese and visit the Cairo museum" (P2-N).

"My brother had doubts about mummies and went to his room to do some research, and suddenly he had photos, videos, and everything on the subject" (P2-O).

Thus, technological knowledge seeks to identify, understand, and know how to use the educational TDIC to facilitate the teaching and learning process; however, this knowledge should not be the teacher's alone, but shared with the student so that they become protagonists and autonomous in their learning, as reported by teacher P3-B: "When the student manages to add one cell to another, they are so happy to realize that they had the capacity to do that."

In short, technological knowledge provides teachers and students with new teaching and learning possibilities, since technology has changed the way of living in society. It is therefore concluded that the greater the technological fluency, the easier it is for teachers to provide students with relevant learning in the context of the digital age.

The difficulties of teachers in using digital technologies

In Class 3, it was evident that the teacher had difficulties mastering the use of digital educational technologies. These difficulties may be related to the age of the teacher, since there are teachers who have had pedagogical training without computers or any other digital technology. Teachers reported that "there are apps that I find super-complicated" (P4-A), as well as that "I think the older a person is, the more difficulty they have in using technology" (P4-B). And, also, that it is very difficult for me because I am not good with apps on my cellphone" (P4-C).

From this perspective, it is possible to interpret that part of the teachers' difficulty in using digital technologies is related to the fear of making mistakes, due to a lack of habit or familiarity with digital technologies, as well as concern of being judged for exposing their difficulty, according to the following reports: "I am not going to use what I am afraid of, so I won't expose my difficulty" (P4-D). And yet, "I think I could better explore each app, but so far I haven't achieved much" (P4-E).

However, this fear can be overcome by practicing the use of digital technologies in class with the students, as reported by teachers P3-A and P4-F. In other words, the teacher learns to master the TDIC by testing its functionalities with the students,

making it clear to the class that it is an experiment to see if it will contribute to the teaching and learning process.

Mizukami (2004) corroborates this discussion by stating that teachers learn during their professional practice. For him, learning as a teacher comes from experimentation (know-how), and not from lectures in a course. To reinforce the author's thinking, it can be seen in the teachers' narrative: "[...] I learn by doing and I have no difficulty in making this clear to my students. I am very open, I am very original about it" (P3-A).

Another teacher describes: "I have to use on a daily basis to learn and face the difficulties" (P4-F),

Difficulty in using the TDIC is not just a lack of mastery by the teachers, but a problem with the app's interface

The reports show that in order for teachers to break away from this fear of using the TDIC in class, some attitudes are necessary, such as asking for help (P3-B), being persistent, and recognizing that it is not possible to know everything (P3-C), being open to change (P4-G), seeking to solve problems and being resilient (P4-H), as well as having a desire to learn (P4-I).

According to Imbernón (2009), these attitudes lead teachers to self-regulate in order to generate significant changes in the local community, as they believe that the presence of digital educational technologies can produce profound changes in the didactics of teaching and ways of learning (KENSKI; 2012).

"We need to break this barrier of fear, that it won't work, and get it into our heads that it will be great. I have a lot of difficulty, and I ask for help sometimes, I experiment, and I see that it is good" (P3-B).

For example, "If it something went wrong, let's start again, I am learning. It is not because you are a teacher that you have to master it" (P3-C).

"Nowadays my head and my classes have changed a lot, I think they have become much more interactive" (P4-G).

"I had to put out the fire, that is how you really learn, I had to go after it, dig in and learn" (P4-H).

"I need to learn everything that technology can facilitate and bring to my class" (P4-I).

Another important aspect is the fact that some apps are not intuitive, and according to Costa (2019), an app for educational purposes should be easy and intuitive: "I think some apps are not intuitive, but maybe the fear of doing something wrong and putting it into practice gets in the way" (P4-J).

Thus, the difficulty in using the TDIC is not just a lack of mastery by the teachers, but a problem with the app's interface. Mishra and Koehler (2006) point out the importance of the teacher's perception of *affordances* - technological resources that allow their functionality to be identified without the need for prior explanation.

Another important issue is the fact that digital technology should not be used every day, but in moderation, and should always be related to the objective of the class, as reported by teacher P4-J: "I only use the app if I think it has to do with the class, I do not use apps in class every day" (P4-J).

Difficulties in using the TDIC are not limited to teachers. Students also have problems accessing the internet and lack of technological infrastructure, which hinders learning, as reported: "I have students who have cellphones that sometimes cannot handle so many apps" (P5-A).

"The big difficulty we face is oscillations with the internet, the students get very annoyed because their voices are often cut off" (P2-A).

From this perspective, we can understand that, on the one hand, teachers and students with professional backgrounds enriched with technological knowledge find it easier to use digital technologies in the classroom, as reported by teacher P3-D: "[...] it is very simple for those who already work in the technological area, in that person's head it is much easier" (P3-D).

On the other hand, teachers with a background and training with little presence of digital technologies have difficulties in using the technologies, which is justified by their social context.

Finally, teachers must rethink their role, break paradigms, acquire new knowledge, adapt to new technologies, as well as innovate in the use of digital technologies in pedagogical practice to overcome these difficulties.

The difficulties of teachers in pedagogical practice

It is important to note that the interpretation of Class 2 is related to Class 3, since both showed similarities. The emphasis of this class is on the difficulties faced in the pedagogical practice in relation to the use of the TDIC. Thus, it can be seen that the difficulties lie in the field of didactics, which, according to Pais (2010), are techniques for transposing scientific knowledge into taught knowledge. According to the reports of teachers P3-A and P3-B, it can be seen that teachers need to understand how they can be didactic (pedagogical) in the use of digital technologies in their classes, since they have the knowledge, but find it difficult to transpose it to the student (didactics).

With regard to this didactic difficulty (pedagogical practice), Mazzardo (2005) explains that there are two moments in didactic transposition: external and internal. The external is the planning of the teaching and learning process, which the teacher intends to mediate. In the internal didactic transposition, it is the path from what was planned (knowledge to be taught) to the knowledge learned by the student.

Thus, there is evidence of the teacher's difficulty in the process of internal didactic transposition. Nascimento (2011) states that specific didactic gestures are necessary for this mediation to take place successfully. Furthermore, the author explains that

specific gestures consist of mediation tools for internalization (learning) by the students. Thus, digital technologies can be considered as part of specific didactic gestures, as the TDIC provide mediation in the act of learning.

It can be considered as "a step by step in technologies. Today, in order to teach the class, the teacher needs someone to hold his hand, it is not because he is a teacher with great knowledge in certain areas that he has to know technologies" (P3-A).

And yet, "the difficulty for the teacher is very great when you use technology to create facilities for your life in class, but suddenly you get there and that message does not reach the student" (P3-B).

As to teacher P1-A's report, it can be seen that the format of communication has changed with the technological advances. Teacher P3-C comments that the new can be scary, for example, when it comes to recording remote and face-to-face classes, which can bring a certain insecurity when conducting the class. However, it is necessary to overcome this fear or insecurity. Nascimento (2011) explains that these movements are called verbal and non-verbal gestures, and they influence the pedagogicals practice and student learning.

"In my days, the way I talked to the student was one, today, with the social network, my communication is different" (P1-A). We can say that "it is in the nature of human beings to be afraid of exposing themselves, and with technology there is no other way, nowadays the class is recorded, it is different when you are talking, that no one heard, so we need to break this barrier of fear" (P3-C).

Teachers have to reinvent themselves, since often what was planned in class does not work or needs to be adapted

In this sense, teachers have to reinvent themselves, since often what was planned in class does not work or needs to be adapted during class due to unforeseen situations, such as internet access (PAIS, 2010; IMBERNÓN, 2009). Thus, it was possible to highlight the importance of specific gestures and pedagogical knowledge to adapt the lesson in a few minutes without losing the quality of learning.

According to teacher P3-E, this insecurity in the teacher's mediation is overcome through practice, through which new teaching and learning possibilities are learned. Thus, "teachers have to reinvent themselves, because if a student does not have access, you cannot leave them out" (P3-D). To get an idea of this process, "before I was afraid it would not work out, I broke that barrier and now I am throwing myself into it and putting into practice, that is how I have been learning" (P3-E).

From this perspective, it is worth remembering that knowledge of pedagogical strategies and mastery of digital technologies are essential for managing the changes and necessary adaptations in the process of transposing planned knowledge into learned knowledge (NASCIMENTO, 2011).

Both teachers P3-F and P4-A agree that the level of technological knowledge contributes to pedagogical mediation. However, it is worth noting that pedagogical mediation is enhanced by human action (teacher-student), and not by digital

technologies (TÉBAR, 2011). "[...] I think it will depend a lot on the teacher's level of technological knowledge" (P3-F and P4-A).

However, the teacher's attitude as to testing and experimenting, without fear of making mistakes, can make it possible to overcome the lack of pedagogical mastery in class, specifically of didactic gestures. To support this attitude, "the teacher has to experiment, without fear of making mistakes, in order to bring all this to the students, the new trends" (P2-A). And "it is worth testing, experimenting, and not being afraid of making mistakes" (P2-B).

Another factor that can negatively interfere with pedagogical practice is the teacher's lack of mastery of the content (MISHRA; KOEHLER, 2006). In this sense, Shulman (1986) comments that this knowledge is essential for the construction of other knowledge, since the greater the teacher's mastery of the subject, the more options for explanations and applications they will have to use in the didactic transposition of scientific knowledge to learned knowledge.

In teacher P4-B's report, it is evident that teachers need to keep constantly updated on curriculum content to overcome this difficulty. For this reason, teacher P1-B emphasizes the importance of teacher's planning, which should take time to study and research so as to propose an appropriate class.

In this context, teacher P3-G's report points to the understanding that the mastery of curriculum content and class planning are considered relevant aspects of the teacher's founding didactic gestures, i.e. they underpin the pedagogical practice (NASCIMENTO, 2011).

Another difficulty in the teacher's pedagogical development is related to the training meetings of teachers

"Teachers need to master the specific area in which they are going to teach the technical course, they cannot give that up" (P3-G). However, "I am afraid to take on a certain subject because it has already changed. For example, the job interview in companies, today there is nothing more to it, that is why I think it is important for the teacher to be up to date" (P4-B).

To mention an example, "the student asked how I use this resource, I did not know how to answer, that is why we (teachers) have to have this extra time to study, to research, to be able to learn and come up with a cool proposal" (P1-B).

Finally, another difficulty in the teacher's pedagogical development is related to the training meetings of teachers. It can be seen, in teacher P3-I's report, that the meetings presuppose that the teacher has the mastery of teaching methodologies (pedagogy) and technological resources. This perception, however, ends up causing fear and frustration regarding the use of digital technologies, as reported by teacher P3-J. For Imbernóm (2009), training should contribute to the teacher's development and the acquisition of new knowledge.

"Training needs to start from the assumption that the teacher does not know that pedagogical tool" (P3-H).

"We go to the courses and the teacher already has to know how to use the technology" (P3-I).

"[...] develop a course so that teachers can fall in love with it, so that they are not afraid to use technology and do not leave thinking they do not know anything yet" (P3-J).

In this sense, the report described above by teacher P1-C suggests the possibility of leveling the teacher's technological pedagogical and content knowledge (MISHRA; KOEHLER, 2006), since if the student perceives this unevenness, it can harm and compromise learning, as well as showing a lack of pedagogical alignment between teachers. "Another important issue is the leveling of the team, as it cannot happen that I get there with a super ultra mega advanced solution and the other teacher cannot keep up" (P1-C).

It can thus be seen, in teacher P3-K's report, that he proposes a training itinerary according to levels of knowledge, i.e. teachers with greater pedagogical difficulties in relation to the use of technologies would take part in separate training and then meet with the other teachers. This training by levels is advocated by Koehler and Mishra (2009), who claim that the inclusion of technology in teacher training should start with the simplest and gradually move on to more complex and sophisticated technologies.

"There are teachers who find it difficult and others who find it easy to use technology, so there needs to be criteria and an itinerary by level. When the teacher arrives at the intermediate level, he joins the others and continues the course" (P3-K).

Finally, it is worth remembering that Mallmann, Schneider and Mazzardo (2014) understand that there are five levels of technological pedagogical knowledge, namely: Level 1 – technical only; Level 2 – technical + pedagogical; Level 3 – pedagogical as support; Level 4 – mediated pedagogical; and Level 5 – transdisciplinarity, autonomy, and virtualization of the teaching-learning process. This proposal for levels of technological-pedagogical fluency could help eliminating these difficulties.

Product: teacher training itinerary

The product is a virtual training environment for teachers of technical professional education based on a training itinerary consisting of videos, texts, games, and quizzes aimed at developing teachers in the use of digital technologies in a pedagogical way, taking into account the curriculum content. This virtual teacher training environment is available at www.educacaoemergente.com and was created by the researcher based on the results of this research.

After this online training, teachers will be invited to a synchronous remote meeting via Microsoft Teams, on the dates and times to be set, with a view of sharing good practices in curating pedagogical content technologies.

Finally, the product is intended to be a reference platform for teacher training based on the TPACK model in Brazil, and will be perfected over the coming months and years as it receives its own or third-party investments.

Final considerations

Pedagogical content knowledge has developed over time, so that the inclusion of technology is necessary in the current context. Digital information and communication technologies have become allies of education, requiring teachers to master the use of these resources.

Thus, TPACK – technological pedagogical and content knowledge addresses this need and proposes that the teachers' knowledge must evolve, as it is not enough for teachers to know how to transpose content in a pedagogical way, but to master the use of the TDIC in this process, in order to make learning meaningful and attractive from the student's point of view.

This clearly aligns with the general objective of the research, which aims to investigate how digital technologies are integrated into teaching practices, based on the theory of technological pedagogical and content knowledge.

From this perspective, the results showed that the pedagogical practice should be enriched with digital technologies through the curation of the TDIC, as the teacher researches, selects, and tests digital resources that are easy, useful, and interactive for the teaching and learning process.

Communication technologies have become allies of education, requiring teachers to master the use of these resources

Thus, it can be concluded from the classes identified that the process of curating digital technologies (Class 5) requires teachers to have technological knowledge (Class 4) in order to develop their pedagogical practice (Class 1). However, there are technological (Class 3) and pedagogical (Class 2) difficulties that hinder the integration of TPACK – technological pedagogical and content knowledge.

The need for pedagogical content knowledge was recurrent in the participants' reports, since the TDIC are resources (means) to facilitate the pedagogical mediation (intent, purpose). However, the need for technological mastery was identified in order to integrate the TDIC into the classes through the process of educational curation, which should be based on the integration of three types of knowledge: technological, pedagogical, and content (TPACK).

With regard to the specific objectives, we identified some of the the TDIC used in the teachers' pedagogical practice: Microsoft Teams, Canvas, Padlet, Word, Excel, PowerPoint, Jamboard, Mentimeter, Wordwall, and MindMeister (mediation technologies). And content-specific programs; Comex, for exports of goods (specific technologies).

The study revealed pedagogical and technological difficulties faced by teachers when using digital technologies. These difficulties are related to the pedagogical domain, such as: pedagogical proposal, pedagogical mediation and assessment through the use of digital technologies, that is, how to make the external and internal didactic transposition using digital resources.

With regard to the difficulties in using the TDIC, it was found that the teachers' and students' lack of technological knowledge could hinder the use of digital technologies, as well as the development of the class.

We noticed that teachers incorporate the use of digital technologies into their professional development through practice, and this involves overcoming the fear of making mistakes and experimenting with the tools in partnership with the students, in order to see if it contributes to learning. Moreover, teacher training courses on the use of digital technologies are based on the assumption that the majority already know them, which ends up hindering the learning of teachers with greater difficulty.

In this context, it was identified the need for teacher training aimed at developing technological knowledge in levels, i.e. a training itinerary that starts with the simplest TDIC and gradually moves on to more complex and sophisticated technologies. Thus, we believe that teacher training should be based on the teachers' difficulties in using the TDIC, which enable experimentation and a relationship with the pedagogical practice and content, with a view to practicing educational curation or technological pedagogical and content knowledge.

In conclusion, the theoretical reference was sufficient for the research, since technology and pedagogy are inseparable for the transposition of content. However, according to the literature review, there were few publications on the subject between 2015 and 2020. It is therefore clear that there is a need to expand our understanding of how the TDIC is being integrated into the pedagogical practice in the technical professional education, given that new digital educational technologies are emerging every day.

As for the contributions and scope of the study, as a researcher, I realized that my pedagogical practice was improved and my understanding of the use of digital technologies that facilitate student learning was enhanced.

The results of this research can be used to train teachers and pedagogical teams in the use of the TDIC in the teaching and learning process, based on the TPACK model. The research, however, was limited to a small sample, which may not represent the whole reality.

We therefore suggest that further studies be carried out in other units and states, with a view to expanding and verifying the data found. This will improve the generalization of the problem. Another relevant aspect to be considered in future research is to understand how each TDIC is being used in teaching practice, in other words, what are the countless possibilities for the pedagogical use of digital technologies in teaching practice.

Note

[1] See more in Tutorial for using the software. Available at: http://www.iramuteq.org/documentation.

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