

ARTICLE

INTEGRATION OF ICT IN TEACHER EDUCATION: APPROACHES BETWEEN THE TPACK MODEL AND THE SOCIOCULTURAL PERSPECTIVE¹

THIAGO BERNARDO CAVASSANI¹

ORCID: <https://orcid.org/0000-0002-5108-5935>

<thiagocavassani@yahoo.com.br>

JOANA DE JESUS DE ANDRADE²

ORCID: <https://orcid.org/0000-0002-6161-2209>

<joanajandrade@ffclrp.usp.br>

ROSEBELLY NUNES MARQUES³

ORCID: <https://orcid.org/0000-0002-8726-3211>

<rosebelly.esalq@usp.br>

¹ Instituto Federal de Educação, Ciência e Tecnologia de São Paulo (IFSP). Catanduva, SP, Brazil.

² Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto (FFCLRP-USP). Ribeirão Preto, SP, Brazil.

³ Escola Superior de Agricultura Luiz de Queiroz (ESALQ-USP). Piracicaba, SP, Brazil.

ABSTRACT: We aimed to conduct a theoretical discussion of the elements that enable reading of the Pedagogical and Content Technological Knowledge (TPACK) model from the perspective of the sociocultural approach. To this end, we present the conceptual structures of the TPACK model and introduce information and communication technologies (ICT) as cultural and symbolic tools to mediate the teacher's pedagogical action. By assuming the concepts of mediation, mastery, and appropriation, arising from the sociocultural approach, we establish a dialogue with the TPACK model to highlight the possible contributions of this reinterpretation to teacher training today. Finally, we discuss the implications of this approach for initial teacher education for and with digital technologies. We hope we will contribute to the discussions underlying teacher research and training, supporting conceptualization that is useful for the research into the modes of interaction mediated by ICT, as well as to the discussion about the factors involved in the ways teachers access, capture, and build professional knowledge in the interface with digital technologies.

Keywords: TPACK, ICT, mediation, mastery, appropriation.

INTEGRAÇÃO DAS TDIC NA FORMAÇÃO DE PROFESSORES: APROXIMAÇÕES ENTRE O MODELO TPACK E A ABORDAGEM SOCIOCULTURAL

RESUMO: O objetivo deste trabalho consiste em discutir teoricamente os elementos que viabilizem a leitura do modelo do Conhecimento Tecnológico Pedagógico e de Conteúdo (TPACK) a partir da

¹ Article published with funding from the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* - CNPq/Brazil for editing, layout and XML conversion services. The translation of this article into English was funded by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES/Brasil.

perspectiva da abordagem sociocultural. Para tanto, apresentam-se as estruturas conceituais do modelo TPACK, introduzindo em seguida as tecnologias digitais da informação e comunicação (TDIC) como ferramentas culturais e simbólicas na mediação da ação pedagógica do professor. Tendo como pressupostos os conceitos de mediação, domínio e apropriação advindos da abordagem sociocultural, estabelece-se um diálogo com o modelo TPACK, a fim de salientar as possíveis contribuições dessa releitura à formação de professores na atualidade. Por fim, são discutidas as implicações dessa aproximação para a formação inicial de professores para e com tecnologias digitais. Desse modo, pretende-se contribuir para as discussões que fundamentam a pesquisa e a prática formativa dos professores, subsidiando uma conceitualização útil à pesquisa dos modos de interação mediadas pelas TDIC, além de compreender os fatores envolvidos nas formas como os docentes acessam, apropriam-se e constroem o conhecimento profissional na interface com as tecnologias digitais.

Palavras-chave: TPACK, TDIC, mediação, domínio, apropriação.

INTEGRACIÓN DE LAS TIC EN LA FORMACIÓN DOCENTE: ENFOQUES ENTRE EL MODELO TPACK Y EL ENFOQUE SOCIOCULTURAL

RESUMEN: Nuestro objetivo fue realizar una discusión teórica sobre los elementos que posibilitan la lectura del modelo Conocimiento Tecnológico Pedagógico y de Contenidos (TPACK) en la perspectiva del enfoque sociocultural. Para ello, presentamos las estructuras conceptuales del modelo TPACK e introducimos las tecnologías digitales de la información y la comunicación (TDIC) como herramientas culturales y simbólicas en la mediación de la acción pedagógica del docente. Teniendo como supuestos los conceptos de mediación, dominio y apropiación, provenientes del enfoque sociocultural, establecemos un diálogo con el modelo TPACK para resaltar los posibles aportes de esta reinterpretación a la formación docente en la actualidad. Finalmente, discutimos las implicaciones de este enfoque para la formación inicial de docentes para y con tecnologías digitales. Esperamos contribuir a las discusiones que subyacen a la investigación y formación docente, apoyando una conceptualización útil para la investigación de los modos de interacción mediados por las TIC, así como para la discusión sobre los factores que intervienen en las formas en que los docentes acceden, captan y construyen conocimiento profesional en la interfaz con las tecnologías digitales.

Palabras clave: TPACK, TIC, mediación, dominio, apropiación.

INTRODUCTION

The context of the COVID-19 pandemic required profound changes in the educational field at practically all levels of education. With the adoption of emergency remote teaching, Digital Information and Communication Technologies (ICT) provided the material possibility for the continuity of the educational process during this period, and educational institutions experienced a significant acceleration in the integration of these technologies into their daily activities. On the other hand, this moment also brought a series of new challenges to teachers' pedagogical practice, highlighting known problems involving the teaching and learning of students in the Brazilian school reality (RYN; SANDARAN, 2020). Among these problems, light was shed on the social and economic inequalities that have long structured Brazilian society, resulting in the suppression of possibilities both for school action and for providing opportunities for the full experience of the educational process for digitally excluded subjects (STEVANIM, 2020). Reports from this period often cite a context of absences: lack of access to quality

Internet, computers, tablets, and cell phones with minimum technical conditions to follow teaching activities; lack of school structure to deal with specific demands; lack of family structure to monitor students' education; lack of access to food with the closure of schools, among others (SOUZA, 2021; DUTRA; FREITAS, 2021; STEVANIM, 2020).

Another challenge highlighted by students and teachers in this context concerns the lack of teacher training for the use of ICT in pedagogical activities (SANTOS; GOES NETO; COELHO, 2021; HONORATO, 2021). Most of the teaching models adopted during the emergency period did not consider the participation of active teachers in the planning and organization of the activities developed, nor did they provide specific moments of training for teachers for the pedagogical use of the resources available for remote teaching (STEVANIM, 2020). The lack of training for teachers for the integration of ICT in teaching activities is not a new fact in the literature. However, at a time when the only possible teaching is that mediated by digital tools, the lack of teachers' knowledge of the use of these digital tools exposed a pressing demand for both teacher training policies and practices in the country.

According to a recent survey by the Internet Steering Committee in Brazil (2021), the proportion of public-school teachers who reported not having experienced specific initial or continuing education activities for the use of ICTs has shown worrying growth since 2015, representing more than 59% of teachers in 2019. The same survey, however, indicated the existence of continuing education courses for teachers offered by educational networks and institutions in the pre-pandemic period, focusing mainly on teaching and learning processes mediated by technologies and the production of digital content. Although these aspects cover part of the demand for work during the emergency teaching period, according to the survey, a rather instrumentalist orientation of technology was observed in the training offered to teachers in practice since topics related to media education, culture, and digital citizenship were developed with less emphasis precisely during the period in which children and adolescents were at greater risk due to increased exposure in the virtual environment.

In any case, national curricular guidelines for initial teacher training have advocated, for some time now, the need for undergraduate courses to integrate the theme of ICTs as a pedagogical tool in their curricula (BRASIL, 2015; 2019). However, training institutions still face significant challenges in fully integrating technologies into the training practices of future teachers (LOPES; FÜRKOTTER, 2020). This scenario is contributed to by the lack of consolidated theoretical frameworks to guide training and educational research concerned with teaching practices at the interface with digital technologies.

Given this scenario, the Technological and Pedagogical Content Knowledge (TPACK) framework has recently gained prominence in national literature as a theoretical model to support educational research and professional teacher training activities (FURTADO et al., 2021; RIBEIRO; PIEDADE, 2021). Updating the Pedagogical Content Knowledge (PCK) model initially proposed by Lee Shulman (1986; 1987), the TPACK framework developed by Mishra and Koehler (2006; 2007) seeks to understand and inform teachers and researchers about the professional knowledge necessary to adequately integrate technologies into their pedagogical activity, also allowing the development of the skills necessary for their didactic task (RIBEIRO; PIEDADE, 2021). As analyzed by Gois (2020), there are still aspects of the theoretical foundation of the TPACK model that give rise to new work by researchers and teachers for its full understanding and eventual use in the educational field. Thus, this framework is often associated with other theoretical and methodological approaches that investigate teacher training and its relationships with ICT.

Thus, this paper aims to present and discuss theoretical elements articulating the TPACK model with the perspective of the sociocultural approach², to provide new subsidies for both teacher training practices and educational research work that intends to use this study orientation. To this end, we initially discuss the TPACK framework and its constructs and then present an understanding of ICT as cultural and symbolic tools in the mediation of the teacher's pedagogical action. Finally, we articulate a vision of the TPACK framework from a sociocultural point of view, anchored mainly in the works of James Wertsch.

TPACK IN TEACHER PERFORMANCE AND EDUCATIONAL RESEARCH

Research that addresses the integration of technologies with pedagogical practice and the specificity of the content worked on in the classroom is increasingly common in current literature. Many of them are conducted based on “[...] empirical findings that result from a great deal of research work that has been carried out in the educational field, but which has lacked a theoretical framework that supports the research and unifies the terminology used by different researchers” (SAMPAIO; COUTINHO, 2011, p. 141). Faced with proposals from several researchers to meet this demand, Punya Mishra and Matthew Koehler (2006) gained greater recognition by presenting a model for integrating these three pillars (technology, pedagogy, and curricular content) into teaching activities in the teaching-learning process (MISHRA; KOEHLER, 2006).

Koehler and Mishra (2009) discuss the specificity, stability, and functional transparency of educational technologies traditionally used in schools. According to the authors, the routine use of different resources (pencils, blackboards, maps, rulers, etc.) gradually transforms them into *natural* objects of the space, which lose their status as technological novelties and become *specific* to that environment. Digital technologies, on the other hand, are relatively more versatile in their use and obsolete than analog technologies. These characteristics give digital tools an unstable character, which carries a certain opacity in their functioning. Thus, they present new challenges for the didactic use of teachers, who must consider the potentialities, possible uses, and limitations of a wider range of tools at their disposal for the teaching and learning process. In this sense, social and contextual variables also assume relevance in the integration between ICT and the teacher's pedagogical practice³.

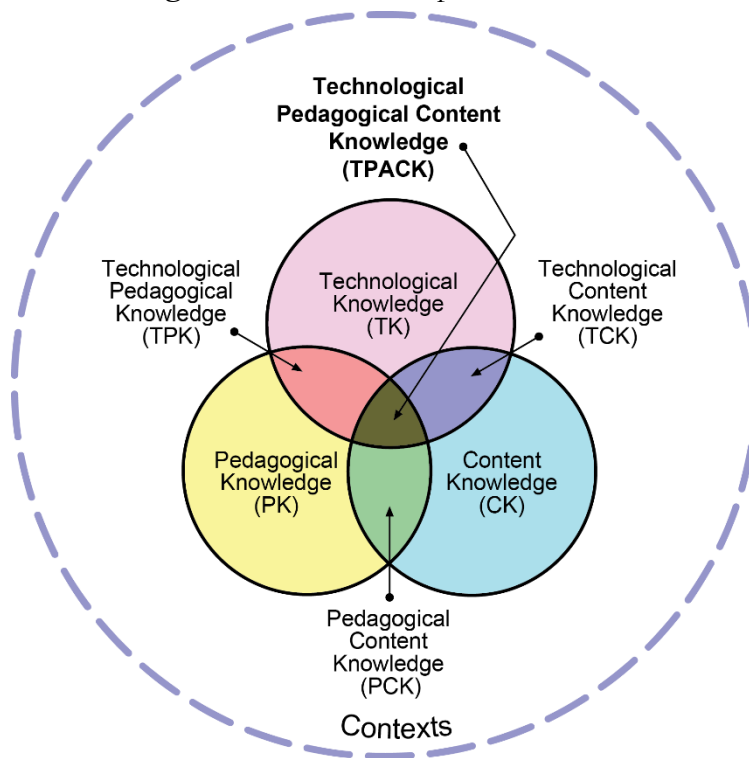
². Arising from the work of a group of Russian scholars from the early 20th century (TOASSA, 2016), the historical-cultural, socio-historical or sociocultural approach (as defined by James Wertsch) focuses on the study of higher psychic functions (attention, perception, memory, language, logical reasoning, emotion and imagination) and is based on the firm assumption that the genesis of human constitution, par excellence, is social relations. Due to this emphasis, social, historical and cultural aspects are constitutive of the axiological bases of the theoretical-methodological proposal of the group. Due to the different readings and interpretations given to the works, mainly Vygotsky's, researchers from different national and international groups do not always converge on a single name. This is also because Vygotsky did not use a specific name. In this article, due to the choice of the study section, the name given by James Wertsch will be used. Another important aspect to be highlighted is the use or not of the term theory before the name. This term may or may not appear as a denominator, depending on the different interpretations adopted. In any case, in our understanding and in agreement with many other scholars, the Vygotskian approach did not reach completion in most of its objects of study, hence the choice of the term approach and not theory. The incompleteness of the work, and everything that this implies in terms of (pre)suppositions, mobilizations and recreations, constitutes not a problem, but one of its greatest legacies.

³ Analog and digital technologies coexist in a state of permanent tension in the school environment. Thus, the TPACK model adapts more appropriately to the approaches that use digital technologies (HARRIS; HOFER, 2011), which does not mean that the importance of analog technologies and their educational use is disregarded or prioritized.

There are many factors involved in the process of integrating ICT into pedagogical activities: teacher training; the suitability of these technologies for official educational purposes; the teacher's conception of the role of education in society; the structural, social, and organizational conditions of the school and those provided for the teacher's work. These issues require recognizing the complexity of this integration and rethinking the teacher's training and modes of action with such tools (KOEHLER; MISHRA, 2009).

Thus, the TPACK conceptual framework can be understood as an explanatory and informative model for teaching training and activity, structured based on the theoretical bases outlined by Shulman (1986; 1987). The main proposal of this model is to offer ways to understand a significant integration between technology, curricular/specific content, and the teaching-learning process, allowing “[...] educators and researchers to prepare teachers who use technology consciously, according to the specificity of educational contexts” (ROSSIT, 2014, p. 29). Normally represented by overlapping concentric circles (figure 1), the TPACK model adds the technological aspect to Shulman's proposal of basic knowledge for teaching, whose intersections give rise to new forms of knowledge re-signified by the need to integrate technology into teaching.

Figure 1 – Schematic representation of the TPACK model



Source: tpack.org.

In addition to Pedagogical Knowledge, Content Knowledge, and Pedagogical Content Knowledge in the terms highlighted by Shulman (1987), Koehler and Mishra (2009) also understand the emergence of other knowledge necessary for the meaning of technologies when integrated into the activity of the contemporary teacher: Technological Knowledge, Technological Content Knowledge, Technological and Pedagogical Knowledge and, finally, TPACK (Chart 1).

Chart 1 – Brief Description of TPACK Constructs

Technological Knowledge	This is knowledge related to new and traditional technologies that can be integrated into the curriculum. It includes knowledge about how to use, modify, and adapt technologies to the needs of use, that is, it indicates a deeper knowledge of ICT for productive use in the various spheres of daily life.
Pedagogical Technological Knowledge	It involves knowledge about how teaching practices can be modified using certain technologies in pedagogical activity. It implies recognizing the possibilities and restrictions that a series of technological tools may present in pedagogical projects and strategies. Its development depends on the expanded understanding of technology affordances in the disciplinary context in which such projects are developed.
Technological Content Knowledge	It concerns knowledge about how technology and content are reciprocally related. Although technology restricts the type of representation possible, newer technologies often provide new and more varied forms of representation; and more flexibility in navigating through these representations.
Technological and Pedagogical Content Knowledge	TPACK is the foundation of good teaching with technology and requires an understanding of how to represent concepts using technology; pedagogical techniques that employ technology constructively to teach content; knowledge of what makes a concept difficult or easy to learn and how technology can help address some of the problems students face; knowledge of students' prior conceptions and theories of epistemology; knowledge of how technology can be used to build on existing knowledge to develop new epistemologies or strengthen old ones.

Source: Adapted from Koehler and Mishra (2009) and Koehler *et al.* (2014).

In many forms of presentation of the TPACK model, the context in which the teacher's knowledge will be used, generated, or transformed represents the structuring backdrop of the entire proposal (MISHRA, 2019).

The basic prerequisite for integrating any technological element into teaching practice is precisely knowing its operating modes, interface, and operational requirements. It is necessary to have the ability to handle and eventually solve technical problems for its use. Instrumental mastery of the use of technologies is an important factor in qualifying for the pedagogical use of ICT. Not knowing the technical tools for integration into the school environment is an obstacle that is sometimes insurmountable for their eventual pedagogical use. In the digital age, the speed at which these devices are modified, updated, created, and discontinued is still noteworthy. Stagnant technological knowledge, considered a product of specific teacher training, would be doomed to become outdated in the face of the obsolescence of digital technologies. In this sense, this form of knowledge is linked to the flow necessary to keep up with changes in information technologies, helping the individual develop an understanding of these resources, and enabling them to select and use them in a way that is consistent with their purposes. Developing technological knowledge involves both a deep vision and mastery of ICT and its applications, as well as the ability to carry out a set of activities and alternative ways of carrying them out through these technologies. This presupposes continuous learning through the use and interaction with different digital technologies (KOEHLER; MISHRA, 2009).

The interaction between technology and the school environment also calls for technological pedagogical knowledge (TPK) that articulates the disciplinary purposes and the structural and social contexts of its use (CIBOTTO; OLIVEIRA, 2017). In this sense, two important aspects related to TPK can be highlighted: the first is that it requires the teacher to know the different technological possibilities

for use in each context and educational activity. The second is to know different pedagogical strategies for the use of these resources and their respective capacity to implement them using technologies appropriately (MISHRA; KOEHLER, 2006; KOEHLER; MISHRA, 2009; ROLANDO et al., 2015). Thus, understanding that many of the technological devices are not developed for educational use, the teacher must know the functionalities offered by these to adapt them to the educational environment (HARRIS; MISHRA; KOEHLER, 2009).

Also, teachers are responsible in their daily activities for a set of specific content, inserted in each area of knowledge (SHULMAN, 1987). Thus, when working with technologies, the basis of teachers' knowledge must be that which articulates curricular content and ICT, recognized in the TPACK model as Technological Content Knowledge (TCK). Analyzing the literature, Oliveira (2017) offers two major definitions for TCK: the first, closer to the original conception of Mishra and Koehler (2006), refers to the understanding of how the forms of content representation are modified with the use of technologies. In another conception, this domain comprises how technology can be used to provide alternative and innovative means for the teaching and learning process of specific concepts. National literature has shown greater agreement with the first definition (SOUZA, 2018; LANG, 2016; ROLANDO et al., 2015).

Once the technological tool appropriate to the objectives and content of the work has been specified, it is possible to suggest a change in the very nature of learning a given school content, creating new cognitive possibilities for the appropriation of concepts, possibly modifying the learning process mediated by the technological tool. Changes in the scope of mediation of forms of learning produced by the technological environment occupy the core of the development of technological content knowledge because as Koehler and Mishra (2009) point out, technologies are responsible for very profound changes in the understanding of various phenomena that are represented as disciplinary content. Understanding this phenomenon “[...] is fundamental for the development of appropriate technological tools for educational purposes” (KOEHLER; MISHRA, 2009, p. 65). According to the authors,

Teachers need to master more than the subject matter they teach; they must also have a deep understanding of how the subject matter (or the types of representations that can be constructed) can be changed by the application of specific technologies. Teachers need to understand which specific technologies are best suited to address learning of the subject matter in their domains and how the content dictates or perhaps even changes the technology—or vice versa. (KOEHLER; MISHRA, 2009, p. 65).

Finally, at the central intersection between technological, pedagogical, and content knowledge, the main construct of Mishra and Koehler's proposal (2006; 2007) emerges, which concerns the planned and significant insertion of technology into the teaching and learning process. This is new knowledge and reflects the interconnection of all domains in practical classroom practice. Given the contingencies that occur in the school environment, the authors argue that there are no prescribed solutions for teaching practice, requiring teachers to continually articulate their knowledge base for classroom practice. Thus, it is necessary to know the curriculum, curricular materials, and content, its possible forms of representation with technologies, and which of these present the best results for certain content. Furthermore, it is necessary to develop the critical capacity to select and evaluate the available technologies considering their shortcomings and possible virtues for use in the classroom. It requires knowing and being able to put into practice a set of pedagogical strategies using these tools that presuppose knowing the students, their ways of learning, their previous concepts, and how these

technologies can facilitate (or not) the learning process. In this way, priority is given to “knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones” (MISHRA; KOEHLER, 2006, p. 1029).

Technological Pedagogical Content Knowledge (TPACK) comprises a complex and multifaceted set of teaching knowledge for teaching specific content in didactic activities oriented and situated for learning that includes learning *with* and *about* technologies, especially digital ones (PALIS, 2010; KURTZ, 2016). Mobilizing TPACK in teaching practice presupposes attention to the ethical dimension in the relationship with technologies, as it demands the necessary criticality both in working with these tools and in generating opportune moments for students to develop this same capacity concerning ICT (YURDAKUL et al., 2012; KURTZ, 2016).

Although the term integration is widely used to describe the dynamics of the articulation between the constitutive dimensions of TPACK, it is important to emphasize the situated characteristic of teaching relationships carried out with digital tools. Thus, the understanding that the teaching activities developed with ICT would inherently correspond to those carried out in their absence, only with the addition of digital resources, is weakened. As Palis (2010) also highlights, there are new interrelations in the actions developed in such a way that the very nature of teaching is modified. With this, it is possible to envision new teaching situations with important changes such as procedural, evaluative, and conceptual development aspects within the pedagogical activity carried out. When integrating technology into teaching processes, care must be taken not to incur mechanical and unconscious technical adherence, changing daily habits so as not to reproduce what is least beneficial about traditionalism in teaching only with the addition of new technologies (PALIS, 2010; MORAN, 2013).

It is also important to outline that the TPACK model proposal involves discussions about possible ambiguities regarding the description and characterization of its constructs (ANGELI; VALANIDES, 2009; OLIVEIRA, 2017), as well as about the possible ways of understanding the model in terms of the very nature of Technological Pedagogical and Content Knowledge. For the scope of this work, this last aspect reveals greater importance, which is why we briefly discuss the two majority understandings about the nature of the central construct of the TPACK model.

The *integrative model* is indicated as originally proposed by Mishra and Koehler (2006), and in it, the TPACK construct emerges from the multiple intersections of the knowledge bases that compose it. Many studies that adopt this understanding direct studies toward the empirical identification of the model's subcomponents, as well as toward the construction and validation of TPACK assessment instruments intended for application in specific sample groups (SCHMIDT et al., 2009; GRAHAM et al., 2009; HARRIS; HOFER, 2011; CHAI et al., 2011; DENG et al., 2017; TONDEUR et al., 2017). However, the predominantly integrative approach of the TPACK model still brings together some issues pending resolution. Although the original proposal advocated this approach (OLIVEIRA, 2017; GRAHAM, 2011), there is an ambiguity between the graphic representation of the model and the form stated by the authors who describe it as a unique and distinctive body of knowledge, closer to the transformative understanding of TPACK, a fundamental issue mitigated in other subsequent publications by the model's proponents (OLIVEIRA, 2017).

Other studies highlight that the conceptual boundaries of the framework's subcomponents may be somewhat imprecise (GRAHAM, 2011; ANGELI; VALANIDES, 2009), a factor that largely results from i) the lack of a clearer definition of the constructs initially idealized; ii) the rapid expansion of theories available in the literature (BRANTLEY-DIAS; ERTMER, 2013; COX; GRAHAM, 2009;

OLIVEIRA, 2017); and iii) the complex nature of the educational act mediated by technologies, which makes it difficult or even impossible to definitively compartmentalize it into a set of theoretical constructs of knowledge or expertise. Approaches that are more closely concerned with observing how teachers develop knowledge for teaching at the interface with digital technologies typically use a transformative perspective of TPACK, suggesting that it indicates a promising path for both educational research and proposals for initial or continuing teacher training.

For Mishra and Koehler (2006; 2009), each teaching activity demands different actions from teachers. To this end, they continually mobilize, on different scales, the knowledge that underpins their professional base in the technological, pedagogical, or content dimensions, in a unique condition for each situation. Therefore, it is precisely the ability to articulate all domains of knowledge that will enable teachers to successfully implement teaching and learning proposals using ICT. It is important not only to develop cognitive capacity and the necessary flexibility in the main domains – technology, pedagogy, and content – but also to understand their possible interrelations for a holistic view of the best forms of action in teaching situations.

By adopting this understanding of the TPACK model, greater attention is given to how the relationships between technologies and teachers' actions are developed in the learning process of teaching or even in their professional practice, observing the intricacies of the construction of professional knowledge for the pedagogical use of ICT. Also, there is often greater attention to the different forms of meaning that subjects present in their relationship with technological tools and their possible implications for their training (initial/continued) or professional practice. Thus, there is a shift from the initial emphasis of research with the TPACK model, which sought to identify teaching knowledge based on the TPACK model through qualitative and quantitative means, to a look at how teachers interact with and signify technology pedagogically, a process by which they construct and modify their knowledge in their relationship with ICT. In this sense, we move towards understanding technology in the broader scope of its role in human relations, in the different forms of mediation of the subject's activity, and in the conception of technology as a cognitive, cultural, and historically developed tool by different social arrangements. By adopting a sociocultural perspective of the relationship between the teacher, technology, and their praxis (KURTZ, 2016; MANGAN, 2016; BERVIAN, 2019; GOIS, 2020), it is possible to advance the broader understanding of the ways of integrating ICT in the school environment and of the analytical role of the TPACK model, with special attention to the teaching activity mediated by ICT.

ICT AS CULTURAL TOOL IN THE MEDIATION OF THE PEDAGOGICAL PROCESS

Looking at ICTs in the ways outlined so far implies recognizing them as important mediators of broader social processes, including how individuals interact with and signify the concrete world around them. Thus, the always mediated interaction between man and the world in contemporary times materialized on the screen, in fiber optics, and headphones, among others and the deprivation or opportunity of access to these technologies shapes how we interact and attribute meaning to concrete reality.

The relationship between man and the world is constructed in a mediated manner by a set of tools (technical and semiotic) available to subjects at a given historical moment. As Wertsch, del Rio, and Alvarez (1998) point out, man's mediated access to the world occurs both in the way subjects access

information and in the way they act in this world, with both instances being dialectically connected. Such questions are based on Vygotsky's (2004) thinking about the role of psychological tools as cultural instruments for the origin and functioning of higher mental functions:

[...] when inserted into the behavioral process, the psychological instrument globally modifies the evolution and structure of psychic functions, and its properties determine the configuration of the new instrumental act in the same way that the technical instrument modifies the process of natural adaptation and determines the form of labor operations (VIGOTSKI, 2004, p. 94).

Vygotsky (2000) highlights the distinction between two mediating elements: technical instruments (external to the subjects) and psychological instruments (internal to the subjects⁴) acting as internal mediators of personal activity. This distinction becomes less significant when considering that, in the adoption of a set of cultural tools in the mediation of the subjects' action, the capacity for social (re)construction of the meanings generated/attributed during a given activity is distributed in the subject-cultural tool dialectic relationship. Thus, technical and psychological instruments can be understood together as the sociocultural toolkit available to the subjects and the agents-acting-with-cultural-tools as the privileged unit of analysis (WERTSCH, 1998).

The focus of Vygotskian analysis was on language (sign) as a psychological tool, through which symbolic mediation would constitute the privileged form of organizing behavior and developing higher psychological functions. The social origin of the forms of mental functioning is based on the sociocultural environment in which each new subject lives will be the guide (conditioner or enabler) of complex processes of internalization, that is, of the meaning not only of concepts and objects but of how social organization functions (WERTSCH, 2002). Vygotsky (2004) also listed several other psychological instruments with similar functions, such as the algebraic system, writing, works of art, drawings, mnemonic processes, and different systems of signs, among others. These artifacts are always constituted by efforts of an individual and collective dimension, mediated by the sociocultural arrangements existing at a given historical moment. Furthermore, they enable/restrict/change the ways of thinking and acting of subjects in a sociocultural context (DANIELS, 2004).

Computers, ICT, and other digital resources can be understood as cultural tools to extend the list of artifacts and tools preliminarily raised by Vygotsky (GIORDAN, 2008). For the limits of the present work, the interaction of subjects with digital tools in school spaces constitutes the mediational means between action and consciousness, so that human action and the very constitution of the subjects' mental functions are largely conditioned/shaped/enabled by the *cultural tools or mediational means* available and used in the subjects' actions (WERTSCH, 1998).

James Wertsch's contributions in this context, as Gomes, Echeverría, and Furtado (2011, n/p) rightly point out, concern the different aspects of human action, whose agency can be understood throughout his work “[...] both in the external field, oriented towards objects, and in the internal field, oriented towards psychological activity, and can be carried out in groups or individually”. Therefore, the author's effort is not focused on just listing the forms of action and ways in which mediation influences

⁴ It is essential to clarify that external and/or internal locations are illustrative. This is because in the dialectical perspective of human interconstitution, there is no basis for the existence and definition of such independent instances, except for the didactic exercise of study. Thus, symbolic materiality exists in instruments such as pencils, hammers, tables, DICTs, but also in the sign terms that describe them. This way of understanding supports the non-division a priori between internal instruments of thought and external instruments of daily life.

this process, but also on highlighting the complex relationship between the agent and the cultural tool that mediates the action as a fundamental unit (GOMES; ECHEVERRIA; FURTADO, 2011).

In this way, the sociocultural perspective contributes to the provision of a consolidated conceptual framework for the analysis of interactive situations in which teachers in training or professional practice use digital tools as learning mediation instruments (GIODAN, 2008). This approach also makes it possible to introduce important elements for the study of the relationship between the formation of professional teaching knowledge and ICT, guiding the microgenesis of how the interaction between individuals and ICT occurs. Considering the notions of mediation and cultural tools initially discussed, we present in the next section some possible approximations between the TPACK model and the sociocultural approach.

SOME ASPECTS OF MEDIATION – APPROACHES TO THE TPACK MODEL

Based on the initial Vygotskian proposal and subsequent developments, Wertsch, del Rio, and Alvarez (1998) highlighted four characteristics common to the different approaches to the issue of mediation, mediational resources, and mediated action. *The dynamic nature of mediation by cultural instruments* is the first attribute listed by Wertsch, del Rio, and Alvarez (1998). The authors state that mediational means have an essentially broad potential to model action, however, they do not “[...] determine or cause action in any kind of static or mechanical way” (WERTSCH; DEL RIO; ALVAREZ, 1998, p. 28). Intentional human action is the primary factor in the implementation of mediation with such tools so mediated action is the result of the potential of these artifacts to model action on the one hand and their intentional and situated use on the other.

In this work, we assume that the introduction of ICT into the flow of actions shapes the possible forms of interaction between students, content, and the intentionally planned pedagogical proposal, providing teachers with the knowledge to recognize such implications and act critically, improving the quality of the teaching and learning process. Developing TPACK, in this context, implies strengthening the ability to recognize such complex dynamics in their work with ICT, overcoming the technocratic tendency to attribute to the mere presence of these cultural tools the ability to improve the educational experience. Guiding one's practice considering the dynamic nature of the processes mediated by ICT requires enabling teachers to understand that situated and intentional pedagogical action, decisions, and contingencies of the modes of interaction with ICT in contact with students are the appropriate instance capable of providing effective learning processes. This strengthens the teacher's decision-making capacity and pedagogical action in processes mediated by digital tools, in contrast to the reductionist conception that advocates the presence of technology as a panacea for complex educational processes.

The second basic characteristic consists of *recognizing mediation as a process*. Thus, the “[...] introduction of a cultural tool into this dynamic process inevitably transforms it” (WERTSCH; DEL RIO; ALVAREZ, 1998, p. 29). The interest in understanding the situational changes in teaching relationships in mediation by ICT allows us to focus on how the introduction of the cultural tool into the flow of the subjects' actions qualitatively transforms the mediated action, regardless of the question of instrumental efficiency or another analytical form (WERTSCH, 2002).

Specifically, the capacity to transform action through the introduction of new cultural tools reflects the need to mobilize and develop TPACK so that teachers understand and act in the

pedagogically oriented integration of digital technologies in teaching activities. The increasingly prominent presence of ICT in school spaces demands an understanding of how teaching activities can be changed through the mediation of such tools, with important repercussions for the students' learning process. To this end, teachers are required to have a set of knowledge specific to this action. In this sense, strengthening TPACK promotes full recognition of how pedagogical activities mediated by digital cultural tools represent actions of a pedagogical nature that are distinct from traditional activities and that do not correspond to the same processes merely added to new digital artifacts. The change in the characteristics of the cultural tool used in the action promotes new forms of representation, means of signification, and other conditions that significantly alter the nature of the pedagogical activity developed. Part of what the TPACK model conceives consists precisely of the specific knowledge of these nuances applied to the teacher's field of knowledge.

These qualitative changes imply that we must also consider the opportunities developed by the introduction of these cultural tools into the actions performed, as well as the limitations imposed. In this sense, Wertsch, del Rio and Alvarez (1998) point out a third characteristic of mediation: *artifacts offer both strengthening and obstacles to the flow of action*. While they present a greater scope for mediated activities, they exhibit other limitations that are normally only understood retrospectively. Specifically referring to the field of technologies: “the new forms of computational mediation [...] undoubtedly have restrictions as well as affordances” (WERTSCH, 2002, p. 107).

Conceptualized in some cases as availability (possibilities, potentialities, or even resources), the concept of affordance was proposed by James Gibson, as analyzed by Maroski (2019). A possible translation of the term concerns the ways “in which objects communicate with us” (CIBOTTO, 2015, p. 69). James Gibson's proposal concerned a possible ability to recognize the functions of certain objects in nature based on their visually perceived characteristics. Concerning various instruments, the intuitive perception of the forms of action and objectives achievable through their use refers to the concept of affordance in a more adjusted way. When observing an object with adequate mass, shape, and size, for example, one can suggest its use as an object suitable for striking or hammering; smaller shapes and mass may indicate its use closer to the throwing activity (MAROSKI, 2019), while blue and red colored marks on taps are intuitive indicators of cold and hot, respectively (CIBOTTO; OLIVEIRA, 2013).

For Wertsch (1998), within the scope of mediated action, the concept of affordance is related to the emergence of new and usually superior forms of thought from the introduction of cultural instruments into human action. As the author points out, however, if there is preferably the overcoming of some previous limitation that the introduction of a certain cultural tool can solve, other and new restrictions are certainly introduced. As can also be inferred from Maroski (2019), the potentialities of these means reflect a relationship between the subjects and intrinsic qualities of the instruments used in the action, so that it does not constitute an exclusive property of cultural tools. According to Daniels (2004, p. 66), “[...] they are not properties of isolated objects, but of objects related to subjects in activity”.

There is currently little room for not recognizing the new possibilities for pedagogical action in the relationship between teachers and ICT, regardless of the teacher's area of knowledge. However, the opportunities offered in this relationship need to be used through strategies that prioritize the students' learning experience (OTREL-CASS; KHOO; COWIE, 2012). This implies, therefore, associating the integration of digital technologies in school spaces with the development of professional knowledge capable of enabling teachers to identify and critically analyze affordances potentially introduced with certain ICT. In addition, it is necessary to recognize the restrictions imbued in the use

of these tools, considering the possible transformations for the representations of content and pedagogical arrangements structured in teaching activity (KOEHLER et al., 2014).

Building TPACK for teachers' performance with digital tools, therefore, involves consciously and critically recognizing how the different tools used in the activity provide possibilities for the organization of teaching and how they can modify the understanding of disciplinary content. It implies understanding the potentials, propensities, and restrictions in the didactic use of ICT, admitting that some of them can be better used for certain tasks (KOEHLER; MISHRA, 2009).

In this aspect of mediation with cultural tools, it is possible to outline new interpretative horizons anchored in the perspective of the sociocultural approach to the constructs initially indicated by Mishra and Koehler (2006) when they suggest, for example, that TPACK is configured by “[...] understanding how technology and content influence and restrict each other” (MISHRA; KOEHLER, 2006, p. 65). Regarding its interrelation with the pedagogical field, Pedagogical Technological Knowledge (TPK) is “[...] an understanding of how teaching and learning can change when particular technologies are used in specific ways”, including “[...] knowledge of pedagogical affordances and constraints” of a variety of technologies in their relationship with the strategy and pedagogical design used (KOEHLER; MISHRA, 2009, p. 65). As Otrell-Cass, Khoo, and Cowie (2012, p. 70) summarize, “[...] when teachers inform their pedagogical practices with their knowledge about affordances of technological resources, they make use of what has been described as [...] TPACK”.

However, the challenges to achieving such objectives are many. As Wertsch, del Rio, and Alvarez (1998) point out, a fourth characteristic of mediation concerns the fact that, in many cases, cultural tools are used in actions that do not necessarily correspond to the purposes for which such artifacts were initially planned or originally used. The authors argue that “[...] the process by which new cultural tools emerged cannot be attributed solely to reflection and conscious decisions about what would best serve as a means of mediation” (WERTSCH; DEL RIO; ALVAREZ, 1998, p. 59). Cultural tools are often used in ways not foreseen in specific actions that they sometimes perform and are also frequently redirected to sociocultural contexts that are quite distinct from those initially used/planned. The potential benefits of using cultural tools in a variety of ways are analyzed by Wertsch, del Rio, and Alvarez (1998) as by-products and may represent more the rule than the exception in the application of various mediational means. This is because certain tools often have their function altered when given new uses that characterize responses to broader sociocultural forces. Considering the differences and limitations, the polysemy of words and the versatility of objects are established as processes of human creativity and social arrangements that give new meaning to words, objects, technologies, as well as objectives and behaviors.

For the competent use of technologies in teaching activities, a set of knowledge is required not only about technology but also willingness and creativity to reconfigure it with the clear objective of improving the learning experience of students (KOEHLER; MISHRA; CAIN, 2013; HARRIS; MISHRA; KOEHLER, 2009). This *competent use* implies, therefore, the redefinition of the concept of mediation in the school environment. This is because the active and responsive role of the teacher in the face of the challenges brought by new technologies is recognized. From the perspective adopted, the mediating teacher, so often cited, approved, or contested, assumes a fundamental role in the sense of choosing, mastering, using, and teaching content and modes of functioning of concepts and instruments. To this end, teachers mobilize and construct the TPACK. The *pedagogical appropriation* of ICT is part of a complex process of mediation and surpasses the most simplistic definitions of the term.

The pedagogical appropriation of cultural tools is often limited by a series of factors, and in some cases occurs partially, intertwined with aspects of the mastery of these artifacts that make it difficult to differentiate the processes. The concept of appropriation gains centrality and condenses the teacher's formative need in guiding his or her deliberate pedagogical action. Thus, in the next section, we highlight the differentiation of the aspects of mastery and pedagogical appropriation of these cultural tools, articulating their relationship with the construction of professional knowledge necessary for the integration of ICT in the context of teaching relationships.

ICT AND TEACHING PRACTICE: BETWEEN MASTERY AND PEDAGOGICAL APPROPRIATION

Another aspect highlighted by Wertsch (1998) and relevant to the present context is his proposal to reconfigure the internalization process initially developed in Vygotskian studies. As highlighted by Giordan (2008), the attention given to the presentation of this proposal is part of the efforts made to broaden the studies on the production of meanings developed by James Wertsch, outlining the concept of internalization within the scope of mediated action and relating it directly to the use of certain cultural tools, as well as to other research problems guided by this theoretical approach. In this understanding, the continuous tension between subjects and cultural tools is taken as a starting point to establish the close link between external actions and mental processes to avoid the mind-body dualism in the approach to internalization processes. Resuming the Vygotskian proposal, Wertsch (1998) signals the treatment of this issue by beginning to conceive it in terms of internalization as mastery and appropriation.

Within the scope of the mastery, Wertsch (1998) indicates the dimension of knowing how to use, of understanding how to use a given cultural tool. The author argues that many forms of action carried out in mediation with cultural tools do not progress in such a way as to be entirely reproducible on an internal level, without disregarding, however, the relevance or changes in these internal dimensions involved in the agent-mediational means tension (WERTSCH, 1998, p. 51). In this relationship, Wertsch (1998) admits the action distributed between the dyad (subject-cultural tool) in the execution of the activity, so that the external means eventually used allow the problem under analysis to be broken down or simplified into a series of tasks with recognizable patterns that are more easily executed by the subjects. From this, the mastery of certain cultural tools leads to the development of specific skills, instead of defining generalizable skills and aptitudes. Although he acknowledges their existence, the author intends to warn about “[...] the temptation to confuse ease with the use of a certain set of cultural tools with some type of general aptitude or intelligence” (WERTSCH, 1998, p. 46). In this sense,

Competence remains associated with mastery and should be seen not as an attribute of the subject, but as evidence of his/her expertise in the use of a [mediational means] in a certain type of action. Furthermore, competence in an action does not imply the subject's ability to perform, on a completely internal or abstract level, that action. (PAULA; MOREIRA, 2014, p. 24).

When we include digital technologies in the scope of teachers' training and professional activity, we are faced with the need to master these tools and develop knowledge for their use. It is desirable to know a set of technological devices with positive potential for the teacher's work, their

characteristics and modes of operation, as well as the ability to solve problems arising from their use. The introduction of technological knowledge into the teacher's knowledge base is the distinctive aspect of the TPACK model and is largely associated with how these cultural tools are mastered in specific circumstances.

Thus, certain skills emerge through using cultural tools (WERTSCH, 1998). The dimension of mastery in this perspective is related to the action mediated by specific cultural tools, used frequently and in specific contexts. Therefore, allowing students (PAULA; MOREIRA, 2014) and teachers in training to conduct their actions, interacting and providing contact with different digital technologies, is an important consequence of this issue in the adaptation and development of the ability to use these resources, as well as for the constitution of the professional teaching repertoire. Encouraging experience with ICT throughout the training path of teachers is a possible means of advancing mastery over the various resources available for teaching, assisting in the continuous development of the teaching knowledge base, and eventually enabling the expansion and new meanings of TPACK for the conscious pedagogical use of ICT.

Mastery of these cultural tools, although an important requirement for effective use in the classroom by teachers, is not enough to guarantee their critical insertion in school spaces. If mastery of these tools refers to competence in carrying out actions mediated by cultural tools, “[...] appropriation implies not only competence in action but also a transformation of the subject, through the unfolding of action in the constitution of their identity processes” (PAULA; MOREIRA, 2014, p. 24). According to Giordan (2008):

[...] knowing how to use a cultural tool does not necessarily mean that the agent takes it as his own, as part of his conceptual horizon. He can simply use it, with different degrees of skill, in situations determined by socio-institutional factors that require it, without recognizing the value of using the tool in other spheres of communication and activity in which he participates (GIORDAN, 2008, p. 96).

Wertsch (1998) distinguishes internalization from appropriation based on Bakhtin's contributions. In this conception, based on the aspects of language with a Bakhtinian focus, appropriation is understood as taking the word belonging to others and making it one's, adding in this process the personal distinctive mark and inserting it into one's way of acting in the world. Appropriation, in addition to the mastery of certain cultural tools, allows the individual to add them to their internal repertoire, enabling them to use them in new contexts and situations different from those originally developed (RIBEIRO, 2018). In this process, they adapt and reflect their objectives in the various mediated actions, to constitute the sociocultural available toolkit to the individual (WERTSCH, 1998). Morales, Casarín, and Salas (2015) summarize this issue well:

[...] one aspect that explains people's cognitive transformations is not precisely the acquisition of the tools but the set of practices that develop around them, that is, the institutional framework in which they are acquired and used, and in this sense, the impact of ICT focuses on the role they play as mediators in people's practices while they use them; in such a way that the result of the appropriation of technological tools supposes the generation of technological awareness in the individuals involved (MORALES; CASARÍN; SALAS, 2015, p.11).

In the context of the construction of professional knowledge by teachers, Gois (2020) indicates the possibility of appropriation of the cultural tool of TPACK by undergraduate students when there are elements indicative of the attribution of meanings to ICT based on situations in which teachers

in training use them expressing their purposes or even with the perception of conflict or resistance in the relationship with technology. The critical view of the relationship between the teacher and the school, the pedagogical activity, and the disciplinary content in the interface with technologies is also an indication of appropriation by the subjects of such cultural tools. For the author, this factor “[...] in addition to being synonymous with a high degree of mastery of a cultural tool, also highlights its appropriation, since [the undergraduate students] are now using it with their intentionality” (GOIS, 2020, p. 14).

Just as TPACK cannot be understood as given knowledge, but rather constructed in different ways in the teacher’s interaction with the various contexts of the use of cultural tools, it can be suggested that the mastery of certain digital resources is related to their pedagogical appropriation at various levels. Wertsch (1998) highlights the distinction between modes of mastery of cultural tools that do not presuppose appropriation, such as the possibility of mastery and appropriation being related to a high or low degree. This relationship does not always occur linearly but rather assumes a complex form that can demonstrate various forms of resistance by subjects as a way of appropriating certain cultural tools. The “[...] differentiation criteria are defined by the agent’s commitment, resistance and autonomy in executing actions with specific purposes” (GIORDAN, 2008, p. 97). Possible resistance to the use of ICT in discourses or proposals for teaching activities are important indicator of how these cultural tools are appropriated by teachers.

Thus, it is reaffirmed that the analysis of the modes of interaction of teachers with ICTs configures a privileged situation of the irreducible tension between the agent and his/her action with the mediational instruments, providing an important unit of analysis (WERTSCH, 1991; 1998) of the forms of mastery and appropriation of cultural tools, as well as the intricacies of the construction of teachers’ professional knowledge. In addition to observing the interactive modes between undergraduate students or teachers working with digital cultural tools, it is also necessary to emphasize the relevance of the production of materials and pedagogical resources by the teacher to recognize them as important methodological instruments indicative of the constitution and development of TPACK.

Regarding the materials and resources produced, Koehler, Shin, and Mishra (2011) state that these can also be understood as methodological forms of accessing and analyzing the TPACK of in-service teachers and with greater relevance for teachers in initial training. The analysis of materials produced in the planning of teaching activities (PAMUK, 2012), or even in other artifacts constructed from the interaction with the ICT systematized in the intentional actions of selection, proposal, evaluation, or pedagogical analysis of these resources, therefore, composes relevant sources of evidence for the development of professional knowledge TPACK (KOEHLER; SHIN; MISHRA, 2011). According to Sampaio and Coutinho (2015, p. 648), it is “[...] during lesson planning, the technological and pedagogical knowledge of teachers is operationalized through the selection, reconciliation, and sequence of learning activities”, and is subject to analysis.

Therefore, the complex agent-cultural tool relationship is crystallized in the different productions and expressions of teachers (analysis of resources/materials produced, teaching activity proposals, construction/use of digital artifacts, interviews, group reports, observation of teaching, etc.). In this process, it is possible to investigate the different ways of mastering and appropriating these mediational means, identifying and promoting the construction of professional teaching knowledge for teaching. In the activity mediated by digital cultural tools, teachers can generate specific purposes of application for these artifacts, based on both the meanings expressed and the productions carried out

and the results of the actions carried out in the school space. This is because, in the interaction with such artifacts, they can recognize their possibilities for pedagogical use, their restrictions within the scope of teaching relationships, and, therefore, valuing the possible changes in the forms of representing content and organizing work, in addition to the possibilities for student learning.

Because it is an activity that demands specific knowledge and skills, there is a possibility of progression in how teachers appropriate these tools pedagogically. This aspect may be present when there is evidence of the use of ICTs for specific or innovative purposes in activities such as the production of teaching materials and resources, in teaching practices, or even in the meanings expressed by subjects in their relationship with these cultural tools. Thus, ICTs are appropriated pedagogically when teachers begin to attribute intentionality to cultural tools in the broader scope of their pedagogical activity. By deliberately inserting them with specific pedagogical purposes, it is possible to scrutinize how they consider the affordances and restrictions of these tools for the desired didactic purpose. It is also possible to highlight the different levels of interaction between mastery and pedagogical appropriation when integrating digital technologies into their pedagogical work, making it possible to investigate how these cultural tools are articulated with the forms of didactic organization implemented and relate to the conceptual content worked on in the classroom.

FINAL CONSIDERATIONS

The role of ICT in teachers' performance and professional training will likely be part of the discussions about the future of education in the post-pandemic scenario. While assessing their relevance and effectiveness for the educational process is a controversial topic in the education community, the integration of digital technologies at the most diverse levels of education has been gaining relevance and may soon occupy a greater space in teaching activities (OLIVEIRA et al., 2021).

Given this, there has also been a growing interest in educational research concerned with the relationships between ICT and initial and continuing teacher training. The TPACK model deserves to be highlighted in this scenario, as its conceptual elements provide a relevant interpretative structure for the approach to professional knowledge in educational research. In addition, the framework contributes a conceptual framework capable of supporting both the theoretical and methodological orientation of research on the construction of professional teacher knowledge and the organization of teacher training practices in their different modalities.

The approximation of the sociocultural approach to the TPACK model allows us to advance in the understanding of the role of the relationships between digital technologies and the actions of subjects, opening the horizon for a look concerned with the intricacies of the forms of integration of these technologies in the school environment and their influence on the modes of action of teachers. In other words, the interconstitutive role of ICT in teaching subjectivity is one of the faces of the teaching and learning process.

In this paper, we highlight the potential of recognizing ICT as a cultural tool and, therefore, as a product of collective sociocultural action developed in the current historical moment. ICTs are understood as privileged mediating instruments, as they enable individuals to access and interact with the world based on the mediation of how subjects identify and signify concrete reality. Within the scope of the constitution of teaching professionalism, the interaction with such artifacts comprises the mediational means between the internal processes of attribution of meanings by teachers and the forms of pedagogical

action developed in the classroom. These processes are largely conditioned, restricted, or amplified in the continuous tension between *agents-acting-with-cultural-tools*. The situated analysis of this relationship provided by the theoretical elements available from the sociocultural approach proves to be potentially relevant for understanding the processes of mastery and pedagogical appropriation of ICT, especially when outlined by the repertoire that constitutes the basis of professional teaching knowledge made available by the TPACK model.

Therefore, it is important to emphasize the importance of initial and continuing teacher training courses promoting the integration of ICT in their curricula, allowing teachers to experience these cultural tools in teaching activities, providing means for their pedagogical appropriation, and the development of professional knowledge for teaching. The TPACK model and the sociocultural approach with the understandings outlined here can provide relevant theoretical support for understanding and guiding the process of integrating ICT in teacher training and performance, whose main objective is to qualify professional teaching performance in search of the continuous improvement of the students' learning experience.

Research using this approach could use some questions to structure its activities, such as: how do the meanings attributed to ICT by teachers relate to the decisions made in their actions in the didactic context? What professional knowledge is involved and how is it mobilized in the processes of using different digital cultural tools by teachers? What attributes of teachers' practices are modified with the integration of ICT? How can the processes of pedagogical appropriation of these cultural tools by teachers be evidenced? How do training practices mediated by cultural tools mobilize and develop teachers' TPACK? Some studies pay attention to some of these questions in the scope of their investigations. Deepening these questions with the approach highlighted here can represent a promising contribution to research on the constitution of the teaching knowledge base and to the organization of initial and continuing teacher training.

REFERENCES

ANGELI, Charoula; VALANIDES, Nicos. Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & education*, v. 52, n. 1, p. 154-168, 2009. <<https://doi.org/10.1016/j.compedu.2008.07.006>>

BERVIAN, Paula V. *Processo de investigação-formação-ação docente: uma perspectiva de constituição do conhecimento tecnológico pedagógico do conteúdo*. Tese (Doutorado em Educação). Ijuí: Universidade Regional do Noroeste do Estado do Rio Grande do Sul, 2019.

BRANTLEY-DIAS, Laurie; ERTMER, Peggy A. Goldilocks and TPACK: Is the construct 'just right?'. *Journal of Research on Technology in Education*, v. 46, n. 2, p. 103-128, 2013. <<https://doi.org/10.1080/15391523.2013.10782615>>

BRASIL. CNE/CP. *Resolução nº 2, de 1º de julho de 2015*. Define as Diretrizes Curriculares Nacionais para a formação inicial em nível superior (cursos de licenciatura, cursos de formação pedagógica para graduados e cursos de segunda licenciatura) e para a formação continuada. Brasília, DF: 2015.

BRASIL. CNE/CP. *Resolução nº 2, de 02 de dezembro de 2019*. Define as Diretrizes Curriculares Nacionais para a formação inicial de professores para a Educação Básica e institui a Base Nacional Comum para a formação inicial de professores da Educação Básica (BNC-Formação). Brasília, DF: 2019.

COMITÊ GESTOR DA INTERNET NO BRASIL. *Pesquisa sobre o uso das tecnologias de informação e comunicação nas escolas brasileiras: TIC educação 2020*. São Paulo: Comitê Gestor da Internet no Brasil, 2021. Disponível em: <https://www.cgi.br/media/docs/publicacoes/2/20211124200326/tic_educacao_2020_livro_eletronico.pdf>. Acesso em 15/08/2022.

CHAI, Ching Sing *et al.* Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education*, v. 57, n. 1, p. 1184-1193, 2011. <<https://doi.org/10.1016/j.compedu.2011.01.007>>

CIBOTTO, Rosefran Adriano Gonçalves. *O uso pedagógico das tecnologias da informação e comunicação na formação de professores: uma experiência na licenciatura em matemática*. Tese (Doutorado em Educação). São Carlos: Universidade Federal de São Carlos, 2015.

CIBOTTO, Rosefran Adriano Gonçalves; OLIVEIRA, Rosa Maria Moraes Anunciato. O conhecimento tecnológico e pedagógico do conteúdo (TPACK) na formação inicial do professor de matemática. In: 8º ENCONTRO DE PRODUÇÃO CIENTÍFICA E TECNOLÓGICA, 2013, Campo Mourão. Anais: Campo Mourão: FECILCAM/NUPEM, 2013. Disponível em: <http://www.fecilcam.br/nupem/anais_viii_epct/PDF/TRABALHOS-COMPLETO/Anais-CET/MATEMATICA/ragcibottotrabalhocompleto.pdf>. Acesso em: 18/02/2022.

CIBOTTO, Rosefran Adriano Gonçalves; OLIVEIRA, Rosa Maria Moraes Anunciato. TPACK – Conhecimento tecnológico e pedagógico do conteúdo: uma revisão teórica. *Imagens Da Educação*, v. 7, n. 2, p. 11-23, 2017. <<https://doi.org/10.4025/imagenseduc.v7i2.34615>>

COX, Suzy; GRAHAM, Charles. Using an elaborated model of the TPACK framework to analyze and depict teacher knowledge. *TechTrends*, v. 53, n. 5, p. 60-69, 2009. <<https://doi.org/10.1007/s11528-009-0327-1>>

DANIELS, Harry. *Vygotsky e a pesquisa*. São Paulo: Edições Loyola, 2004.

DENG, Feng *et al.* Examining the validity of the technological pedagogical content knowledge (TPACK) framework for preservice chemistry teachers. *Australasian Journal of Educational Technology*, v. 33, n. 3, p. 1-14, 2017. <<https://doi.org/10.14742/ajet.3508>>

DUTRA, Maria de Fátima da Conceição; FREITAS, Renan Moura. Os interesses do empresariado no ensino remoto e a desigualdade educacional no Brasil no contexto da pandemia. *Ensino em Perspectivas*, v. 2, n. 2, p. 1–17, 2021. Disponível em: <<https://revistas.uece.br/index.php/ensinoemperspectivas/article/view/5080/4056>>. Acesso em: 16/08/2022.

FURTADO, Maycon Nise *et al.* Desafios e oportunidades do uso da tecnologia na prática docente: uma revisão em torno do TPACK no Brasil. *#Tear: Revista de Educação, Ciência e Tecnologia*, v. 10, n. 1, 2021. <<https://doi.org/10.35819/tear.v10.n1.a4792>>

GIORDAN, Marcelo. *Computadores e linguagens nas aulas de ciências: uma perspectiva sociocultural para compreender a construção de significados*. Ijuí: Editora Unijuí, 2008.

GOIS, Jackson. TIC como ferramenta cultural no ensino superior em Química. #Tear. *Revista de Educação, Ciência e Tecnologia*, v. 9, n. 2, p. 1-21, 2020. <<https://doi.org/10.35819/tear.v9.n2.a4106>>

GOMES, Ivan Carlos Pereira; ECHEVERRÍA, Agustina Rosa; FURTADO, Wagner Wilson. A mediação semiótica dos instrumentos culturais na aprendizagem de conceitos científicos. In: 8º ENCONTRO NACIONAL DE PESQUISA EM EDUCAÇÃO EM CIÊNCIAS, 2011, Campinas. Anais. Campinas: ENPEC, 2011. Disponível em: <http://abrapecnet.org.br/atas_enpec/viii/enpec/resumos/R0334-1.pdf>. Acesso em: 15/08/2022.

GRAHAM, Charles *et al.* Measuring the TPACK confidence of inservice science teachers. *TechTrends*, v. 53, n. 5, p. 70-79, 2009. <<https://doi.org/10.1007/s11528-009-0328-0>>

GRAHAM, Charles. Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education*, v. 57, n. 3, p. 1953-1960, 2011. <<https://doi.org/10.1016/j.compedu.2011.04.010>>

HARRIS, Judith; HOFER, Mark. Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education*, v. 43, n. 3, p. 211-229, 2011. <<https://doi.org/10.1080/15391523.2011.10782570>>

HARRIS, Judith; MISHRA, Punya; KOEHLER, Matthew. Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. *Journal of Research on Technology in Education*, v. 41, n. 4, p. 393-416, 2009. <<https://doi.org/10.1080/15391523.2009.10782536>>

HONORATO, Hércules Guimarães. Os meandros da educação e da aprendizagem em meio à pandemia covid-19: os desafios e as lições. *REVES: Revista Relações Sociais*, v. 4, n. 1, p. 1-19, 2021. <<https://doi.org/10.18540/revesv4iss1pp01001-01019>>

KOEHLER, Matthew *et al.* The technological pedagogical content knowledge framework. In: SPECTOR, Jonathan Michael *et al.* (ed.). *Handbook of research on educational communications and technology*. New York: Springer, 2014. p. 101-111.

KOEHLER, Matthew; MISHRA, Punya. What is technological pedagogical content knowledge? *Contemporary issues in technology and teacher education*, v. 9, n. 1. p. 60-70, 2009. Disponível em: <<https://citejournal.org/volume-9/issue-1-09/general/what-is-technological-pedagogical-content-knowledge/>>. Acesso em: 15/08/2022.

KOEHLER, Matthew; SHIN, Tae Seob; MISHRA, Punya. How do we measure TPACK? Let me count the ways. In: RONA, Robert; RAKES, Christopher; NIESS, Margareth. (Ed.). *Educational Technology, Teacher Knowledge, and Classroom Impact: A Research Handbook on Frameworks and Approaches*. Hershey: IGI Global, 2011. p. 16-31.

KOEHLER, Matthew; MISHRA, Punya; CAIN, William. What is technological pedagogical content knowledge (TPACK)? *Journal of Education*, v. 193, n. 3, p. 13-19, 2013. <<https://doi.org/10.1177/002205741319300303>>

KURTZ, Fabiana Diniz. Ensino e aprendizagem “com” e não apenas “sobre” tecnologias: contribuições para o ensino superior e formação docente a partir da abordagem histórico-cultural de Vigotski. *Ensino de Ciências e Tecnologia em Revista*, v. 6, n. 1, p. 83-99, 2016. <<https://doi.org/10.20912/2237-4450/v6i1.1672>>

- LANG, Affonso Manoel Righi. *O Desenvolvimento do Conhecimento Pedagógico Tecnológico do Conteúdo de Professores do Ensino Fundamental*. Dissertação (Mestrado em Desenvolvimento Humano e Tecnologias). Rio Claro: Universidade Estadual Paulista Júlio de Mesquita Filho, 2016.
- LOPES, Rosemara Perpétua; FÜRKOTTER, Monica. Do projeto pedagógico à aula universitária: aprender a ensinar com TDIC em cursos de licenciatura em matemática. *Educação em Revista*, v. 36, e220954, 2020. <<https://doi.org/10.1590/0102-4698220954>>
- MANGAN, Jeniffer. *Enhancing teachers' use of web-based resources: A case study of secondary technology teachers*. 2016. Tese (Doutorado em Filosofia). Hamilton: University of Waikato, 2016.
- MAROSKI, Marcelo Wachter. *A Teoria das Affordances como ferramenta de análise para uma proposta de ensino de vetores utilizando o software GeoGebra*. Monografia (Licenciatura em Matemática). Ijuí: Universidade Regional do Noroeste do Estado do Rio Grande do Sul, 2019.
- MISHRA, Punya. Considering contextual knowledge: The TPACK diagram gets an upgrade. *Journal of Digital Learning in Teacher Education*, v. 35, n. 2, p. 76-78, 2019. <<https://doi.org/10.1080/21532974.2019.1588611>>
- MISHRA, Punya; KOEHLER, Matthew. Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, v. 108, n. 6, p. 1017-1054, 2006. Disponível em: <http://one2oneheights.pbworks.com/f/MISHRA_PUNYA.pdf>. Acesso em: 14/08/2022.
- MISHRA, Punya; KOEHLER, Matthew. Technological Pedagogical Content Knowledge (TPCK): Confronting the Wicked Problems of Teaching with Technology. In: *Society For Information Technology & Teacher Education International Conference*, 2007, San Antonio. Anais. Waynesville: Association for the Advancement of Computing in Education, 2007. Disponível em: <<https://www.learntechlib.org/p/24919/>>. Acesso em 17/10/2020.
- MORALES, Katuska Fernández; CASARÍN, Alma Vallejo; SALAS, Lewis McAnally. Apropiação tecnológica: una visión desde los modelos y las teorías que la explican. *Perspectiva Educacional, Formación de Profesores*. v. 54, n. 2, p. 109-125, 2015. <10.4151/07189729-Vol.54-Iss.2-Art.331>
- MORAN, José Manuel. Ensino e Aprendizagem inovadores com apoio de tecnologias. In: MORAN, José Manuel; MASETTO, Marcos Tarciso; BEHRENS, Marilda Aparecida. (Orgs.). *Novas tecnologias e mediação pedagógica*. 21. ed. Campinas: Papirus, 2013, p.11-72.
- OLIVEIRA, Máira Marques. *Conhecimento pedagógico e tecnológico do conteúdo na formação de professores na educação científica e tecnológica*. Dissertação (Mestrado em Educação Científica e Tecnológica). Florianópolis: Universidade Federal de Santa Catarina, 2017.
- OLIVEIRA, Muriel Batista *et al.* O ensino híbrido no brasil após pandemia do Covid-19. *Brazilian Journal of Development*, v. 7, n. 1, p. 918-932, 2021. <<https://doi.org/10.34117/bjdv7n1-061>>
- OTREL-CASS, Kathrin; KHOO, Elaine; COWIE, Bronwen. Scaffolding with and through videos: An example of ICT-TPACK. *Contemporary Issues in Technology and Teacher Education*, v. 12, n. 4, p. 369- 390, 2012. Disponível em: <<https://citejournal.org/volume-12/issue-4-12/science/scaffolding-with-and-through-videos-an-example-of-ict-tpack/>>. Acesso em: 16/08/2022.
- PALIS, Gilda de La Rocque. O conhecimento tecnológico, pedagógico e do conteúdo do professor de Matemática. *Educação Matemática Pesquisa*, v. 12, n. 3, p. 432-451, 2010. Disponível em: <<https://revistas.pucsp.br/index.php/emp/article/view/4288>>. Acesso em: 17/02/2021.

PAMUK, Sonmez Understanding preservice teachers' technology use through TPACK framework. *Journal of Computer Assisted Learning*, v. 28, n. 5, p. 425–439, 2012. <<https://doi.org/10.1111/j.1365-2729.2011.00447.x>>

PAULA, Helder Figueiredo; MOREIRA, Adelson Fernandes. Atividade, ação mediada e avaliação escolar. *Educação em Revista*, v. 30, n. 1, p. 17-36, 2014. <<https://doi.org/10.1590/S0102-46982014000100002>>

RIBEIRO, Priscila Ramos Lara; PIEDADE, João Manuel Nunes. Revisão sistemática de estudos sobre TPACK na formação de professores no Brasil e em Portugal. *Revista Educação em Questão*, v. 59, n. 59, p. 1-26, 2021. <<https://doi.org/10.21680/1981-1802.2021v59n59ID24458>>

RIBEIRO, Rayane Kelly Pereira. *Produção de significados utilizando o jogo planeta Química com base na teoria da ação mediada*. 2018. Dissertação (Mestrado em Ensino de Ciências e Matemática). São Luís: Universidade Federal do Maranhão, 2018.

ROLANDO, Luis Gustavo Ribeiro *et al.* Integração entre internet e prática docente de Química. *Revista Virtual de Química*, v.7, n 3, p. 864-879, 2015. <<https://doi.org/10.5935/1984-6835.20150044>>

ROSSIT, Fernando Henrique Andrade. *Educação musical à distância: Base de Conhecimento Docente para o Ensino de Teclado*. Dissertação (Mestrado em Educação). São Carlos: Universidade Federal de São Carlos, 2014.

RYN, Ang Sher; SANDARAN, Shanti Chandran. Teachers' Practices and Perceptions of the Use of ICT in ELT Classrooms in the Pre-Covid 19 Pandemic Era and Suggestions for the 'New Normal'. *LSP International Journal*, v. 7, n. 1, p. 99–119, 2020. <<https://doi.org/10.11113/lspi.v7n1.100>>

SAMPAIO, Patrícia Alexandra Silva Ribeiro; COUTINHO, Clara Pereira. Formação Continua de Professores: Integração das TIC. *Revista da Faculdade em Educação*, n. 1, v. 15, p. 139-151, 2011. Disponível em: <<https://periodicos.unemat.br/index.php/ppgedu/article/view/3789>>. Acesso em: 17/02/2022.

SAMPAIO, Patrícia Alexandra Silva Ribeiro; COUTINHO, Clara Pereira O professor como construtor do currículo: integração da tecnologia em atividades de aprendizagem de matemática. *Revista brasileira de educação*, v. 20, n. 62, p. 635-661, 2015. <<https://doi.org/10.1590/S1413-24782015206205>>

SANTOS, Juliana Ferreira; GOES NETO, Antônio Fernandes; COELHO, Patrícia Margarida Farias. Acesso à educação e à tecnologia: desafios em tempos de pandemia. *Educação & Linguagem*, v. 24, n 2, p. 411-429, 2021. <<https://doi.org/10.15603/2176-1043/el.v24n2p411-429>>

SCHMIDT, Denise *et al.* Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, v. 42, n. 2, p. 123–149, 2009. <<https://doi.org/10.1080/15391523.2009.10782544>>

SHULMAN, Lee. Knowledge and Teaching Foundations of the New Reform. *Harvard Educational Review*, v. 57, n. 1, p. 1-22, 1987. <<https://doi.org/10.17763/haer.57.1.j463w79r56455411>>

SHULMAN, Lee. Those who understand: Knowledge growth in teaching. *Educational Researcher*, v. 15, n. 2, p. 4-14, 1986. <<https://doi.org/10.2307/1175860>>

SOUZA, André Henrique Silva. *Integrando tecnologias no ensino de ciências: como formar licenciandos para o século 21?* Dissertação (Mestrado em Ensino em Biociências e Saúde). Rio de Janeiro: Fundação Oswaldo Cruz, 2018.

SOUZA, Tiago Santana. Challenges of the teacher in the pandemic. *Journal of Gender and Interdisciplinarity*, v. 2, n. 05, p. 95-107, 2021. <<https://doi.org/10.51249/gei.v2i05.514>>

STEVANIM, Luiz Felipe. Exclusão nada remota: desigualdades sociais e digitais dificultam a garantia do direito à educação na pandemia. *RADIS: Comunicação e Saúde*, n. 215, p. 10-15, 2020. Disponível em: <<https://www.arca.fiocruz.br/bitstream/icict/43180/2/Exclus%c3%a3oNadaRemota.pdf>>. Acesso em: 16/02/2022.

TOASSA, Gisele. "Atrás da consciência, está a vida": o afastamento teórico Leontiev-Vigotski na dinâmica dos círculos vigotskianos. *Educação & Sociedade*, v. 37, n. 135, p. 445-462, 2016. <<https://doi.org/10.1590/ES0101-73302016144457>>

TONDEUR, Jo *et al.* Developing a validated instrument to measure preservice teachers' ICT competencies: Meeting the demands of the 21st century. *British Journal of Educational Technology*, v. 48, n. 2, p. 462-472, 2017. <<https://doi.org/10.1111/bjet.12380>>

TPACK.ORG. Using the TPACK Image. Disponível em: <<https://tpack.org/tpack-image/>>. Acesso em 05/08/2024.

VIGOTSKI, Lev Semionovitch. *A formação social da mente*. 6 ed. São Paulo: Martins Fontes, 2000.

VIGOTSKI, Lev Semionovitch. *Teoria e método em psicologia*. São Paulo: Martins Fontes, 2004.

WERTSCH, James. Computer mediation, PBL, and dialogicality. *Distance Education*, v. 23, n. 1, p. 105-108, 2002. <<https://doi.org/10.1080/01587910220124008>>

WERTSCH, James. *Mind as action*. New York: Oxford University Press, 1998.

WERTSCH, James. *Voices of the mind: Sociocultural approach to mediated action*. Cambridge: Harvard University Press, 1991.

WERTSCH, James; DEL RIO, Pablo; ALVAREZ, Amelia. Estudos socioculturais: história, ação e mediação. In: WERTSCH, James; DEL RIO, Pablo; ALVAREZ, Amelia (Orgs.). *Estudos socioculturais da mente*. Porto Alegre: ArtMed, 1998, p. 11-41.

YURDAKUL, Isil Kabakci *et al.* The development, validity and reliability of TPACK-deep: A technological pedagogical content knowledge scale. *Computers & Education*, v. 58, n. 3, p. 964-977, 2012. <<https://doi.org/10.1016/j.compedu.2011.10.012>>

Submitted: 09/21/2022

Preprint: 09/20/2022

Approved: 05/04/2023

AUTHORS' CONTRIBUTION

Author 1 - Conceptualization. Theoretical-methodological frameworks. Preparation, creation, writing and submission of the initial version of the work.

Author 2 - Conceptualization. Theoretical-methodological frameworks. Critical review and editing of the initial version of the work.

Author 3 - Project supervision. Research coordination activity. Conceptualization. Review of the initial version of the work.

DECLARATION OF CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with this article.