The integration of technology in university teachers following the TPACK Model

La integración de la tecnología en los docentes universitarios siguiendo el modelo TPACK

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Dulce Elena López Sánchez*
Guadalupe González Romero**

Keywords
Technology; teacher; technological integration; TPACK model

ABSTRACT

The objective of this research focused on identifying the level of technological integration that university professors of the Faculty of Accounting and Administration of Autonomous University of Sinaloa, México, possess, based on the TPACK model during their teaching practice. The results were determined using the criterion of mean frequencies (M), where the low level of conceptual knowledge corresponds to M£2.3, for an intermediate level M>2.3 and M£3.6 and for the high-level M>3.6. These findings showed that the teachers were, in general, above the mean in the seven dimensions of knowledge that make up the model (M=3.6). The data reflected that the teachers were at a high conceptual level of technological integration due to their level of knowledge. It was shown that the hypothesis is true, since the teaching activities that promote learning are related to the level of technological integration following the TPACK model. Future lines of research may include direct observation of educational practices in the classroom to advance towards greater scientific knowledge about the integration of technological tools in the design and development of teaching activities with technology.

Palabras clave
Tecnología; docente; integración tecnológica; modelo TPACK

RESUMEN

El objetivo de esta investigación se centró en identificar el nivel de integración tecnológica que poseen los docentes universitarios de la facultad de Contaduría y Administración de la Universidad Autónoma de Sinaloa, México, a partir del modelo TPACK durante su práctica docente. Los resultados fueron determinados mediante el criterio de frecuencias medias (M), donde el nivel bajo de conocimiento conceptual corresponde a M£2.3, para un nivel intermedio M>2.3 y M£3.6 y para el nivel alto M>3.6. Estos hallazgos mostraron que los docentes se encuentran, de manera general, por encima de la media en las siete dimensiones del conocimiento que conforman el modelo (M=3.6). Los datos reflejaron que los profesores se encontraban en un nivel conceptual de integración tecnológica alta debido a su nivel de conocimientos. Se demostró que la hipótesis es verdadera, ya que las actividades de enseñanza promotoras del aprendizaje se relacionan con el nivel de integración tecnológica siguiendo el modelo TPACK. Las líneas de investigación a futuro pueden incluir la observación directa de las prácticas educativas en el aula, para avanzar hacia un mayor conocimiento científico respecto a la integración de las herramientas tecnológicas en el diseño y desarrollo de las actividades de enseñanza con tecnología.

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* Doctora en Educación por la Universidad Autónoma de Sinaloa. Profesora investigadora de la Universidad Autónoma de Sinaloa, México. ORCID: https:// orcid.org/0000-0002-2365-6446, correo electrónico: delenalosano1@gmail.com | ** Doctora en Educación por la Universidad Autónoma de Sinaloa. Profesora investigadora de la Universidad Autónoma de Sinaloa, México. ORCID: https://orcid.org/0009-0008-8424-696X, correo electrónico: lupitagr@gmail.com

INTRODUCTION

Information and communication technologies (ICT) have been successfully incorporated in numerous fields of action and in diverse areas. However, it seems that in the educational field the integration of technologies has not achieved the expected impact and results (Flores and Ortíz, 2019; Céspedes, 2021; Márquez, 2021; López and Chávez, 2013; Pastor, 2006; Soto, 2014) or else, the process is advancing slower compared to other areas. This is attributed, among other factors, to barriers associated with conditions, the context in schools and teachers' beliefs (Guerra and Jordán, 2010; Leal and Rojas, 2020).

The unexpected and unstable situation caused by the covid-19 pandemic increased society's need to access and connect through ICTs, which became part of daily routines. This change conditioned lifestyles, daily habits and customs, as well as priorities and the educational context. The suspension of face-to-face activities and the transition to the virtual modality forced the search for and adoption of new ways of establishing relationships between teachers and students, resulting in the rapid transformation of the teaching-learning process.

In this change, ICTs have played a fundamental role, as well as the collaboration of families and the ability of teachers to adapt and participate. ICTs have enabled the exchange of educational material and participation in virtual classrooms, as well as favoring social interaction among members of the community. Therefore, one of the initial steps in carrying out this task is to begin with the training and improvement of the social and working conditions of the teaching staff, so that they can respond to expectations effectively.

In this sense, it is essential to take into account aspects such as: the teacher's level of knowledge about the subject and his or her competencies and skills, as well as the mastery he or she has over ICT. In addition, teachers require that the conditions of equipment and technological infrastructure in their work environment are spaces that respond to the needs to optimally develop their practice.

This research was conducted with the objective of analyzing the level of technological integration that university teachers have to carry out teaching activities during their teaching practice, based on the seven dimensions of knowledge of the model known as TPACK (Technological Pedagogical Content Knowledge).

The proposal has been based on the teacher identifying the level of conceptual, pedagogical and technological knowledge he/she possesses, since it is fundamental for him/her to be able to optimize and innovate his/her teaching practice, as well as to promote learning in students. The hypothesis of this study is that the level of technological integration of

university teachers is mainly affected by a low level (M≤2.3) in the dimension of technological knowledge.

The results of this research will be useful for those who formulate and implement university teacher updating policies, since it will allow them to build with greater accuracy and empirical evidence strategies for the training and updating of teaching staff, to provide them not only with the necessary knowledge for the technical use of technologies, but also with training that allows them to integrate the pedagogical element when they use them. Thus, based on this knowledge, in each activity of their practice, teachers will resort to the use of the technological tools they possess.

METHODOLOGY

Some of the studies conducted under the TPACK model, such as Doukakis *et al*. (2021), examined the level of technological and pedagogical knowledge and its integration by teachers and found that they have a high level of knowledge about their subject content and technology, but are less confident in their pedagogical and technological knowledge of the content. Other research has focused on teachers who teach online, such as Lima and Flores (2018), who studied tutors in virtual classrooms and found marked differences in their technological knowledge, with a low culture of ICT integration.

Regarding trainee teachers, research by Leal and Rojas (2020) indicates the existence of negative correlations in pedagogical and technological knowledge of content. For their part, Oyanagi and Satake (2016) explored changes in pre-service teachers' TPACK during their practice through MindMap. Koh and Divaharan (2011) found that prospective teachers have predominantly developed technological and technological-pedagogical knowledge, so they conclude that, in general, there is a positive attitude towards learning and using ICT, which coincides with the study of Sáez (2010), who found that teachers show a positive attitude towards using and integrating technological tools. Lee and Kim (2014) revealed that teachers have difficulty understanding pedagogical knowledge, which hinders the incorporation of TPACK.

For example, Leal and Rojas (2020) found no significant differences with respect to gender; however, the findings of Cabero *et al*. (2014) indicate a dissimilarity between male and female professors, and reveal that men, in general, achieve better scores than women in all the knowledge dimensions measured by the TPACK and show greater technological integration.

According to the results of the studies, the greatest difficulty faced by teachers lies in how to put technology at the service of their teaching

activities, i.e., how to integrate technology and pedagogy in their educational practice, although it should be noted that the number of studies on this subject is scarce. In this sense, the findings of the study conducted by Roig-Vila and Flores (2014) show that teachers navigate more easily in the dimension of content knowledge, where they have high levels of knowledge about the content of the subjects they teach, but this is not the case with respect to technological knowledge, where their knowledge is lower or they have problems keeping up to date.

Recently, the National Association of Universities and Higher Education Institutions (ANUIES, by its acronym in Spanish) has designed the Institutional Development Plan Vision 2030, which highlights the lines of action to promote the use of ICTs and their conversion to learning and knowledge technologies (LKT) in educational programs. In addition, it is recognized that institutions are distinguished and strengthened through innovative practices to improve the use of ICT (ANUIES, 2021).

According to research, the Autonomous University of Sinaloa (UAS) has not achieved the expected impact in school classrooms (López and Chávez, 2013; Pastor, 2006; Soto, 2014; Urías, 2016), even though its policies are aligned with international guidelines and prioritize the training processes of its teachers through refresher courses for them to appropriate technological tools and incorporate them into their teaching practice (Madueña, 2021; Guerra, 2013; Corrales, 2011).

The study population of this research comprises university teachers at the higher level of the School of Accounting and Administration of the UAS of the Central Regional Unit (URC).

RESULTS

Statistical analyses were carried out involving the use of Cronbach's Alpha coefficient, inter-item correlation and the calculation of Cronbach's Alpha when eliminating an item. Statistical Package for the Social Sciences (SPSS), version 23, was used to perform these analyses.

The following sociodemographic information was collected for the TPACK survey: gender, age, schooling, initial training, years of service, type of contract and modalities of teaching. To better understand the process developed in this research, the instrument used is described in depth.

TPACK Questionnaire Instrument

This is a research resource developed in 2009 by Schmidt *et al.* aimed at teachers in training, translated and adapted to Spanish by Cabero *et al.* (2014). It is a multidimensional instrument consisting of 46 items, with a

Likert-type scale of five response options, in which value 1 equals "strongly disagree", 2 equals "disagree", 3 equals "neither agree nor disagree", 4 equals "agree" and 5 equals "strongly agree". This resource measures the following seven dimensions: technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPACK).

This instrument has been widely used to assess teacher technology integration, and has been shown to have acceptable psychometric properties in several validation studies (Nordin and Faekah, 2016; Yeh *et al.*, 2014; Jang and Tsai, 2012; Koh *et al.*, 2010; Schmidt *et al.*, 2009).

The sample consisted of 125 teachers from the School of Accounting and Administration of the Autonomous University of Sinaloa, belonging to the central regional unit (Culiacán), who responded to all the survey items.

General aspects of the sample

According to the data collected, of the 125 teachers, 48.8% were men and 51.2% were women, and almost 69% were between 30 and 50 years of age. In terms of academic training, 41% of the teachers had obtained a master's degree, while 50.4% had less than ten years of experience. Regarding their initial training, 57.6% had a bachelor's degree in business administration and public accounting. On the other hand, 46.4% of the teachers had a basic subject contract, and 70.4% taught in the school-based modality.

TPACK Survey

The results obtained through this survey contributed to answer the research question on the level of technological integration that university teachers possess based on the dimensions of knowledge of the TPACK model, and are presented according to the seven dimensions of knowledge of the TPACK model. It should be noted that the order of the dimensions is not established according to the level of importance. In addition, an analysis was carried out to determine whether there are significant differences in the knowledge dimensions of the TPACK model in relation to age, years of service, type of contract, gender, schooling and initial training.

Technological knowledge

This dimension identifies the knowledge that teachers have about the technological tools they use to develop their activities (Mishra and Koehler, 2006). According to the results, 85.6% of the teachers affirmed that they "agree" and "strongly agree" with respect to their ease of acquiring technological knowledge and solving technical problems in their

teaching work; however, only 30.4% expressed feeling updated in relation to new technological tools. No significant difference was found between the gender of the participants. In addition, it was observed that 39.4% of the teachers were in the age range between 31 and 40 years, a finding that coincides with the study conducted by Roig-Vila and Flores (2014), in which teachers reported difficulties in keeping up to date with technological developments.

Among the statements, the item referring to knowing a great variety of technologies registers the lowest mean (M=3.64), while the highest corresponds to the item about easily assimilating technological knowledge (M=4.30). Of the participants, only 7.2% are between 21 and 30 years of age, while approximately 42% are in the 31-40 age range. This finding is similar to that obtained by Cabero *et al.* (2014), who obtained as a result a mean of 4.22, only eight hundredths less than what was obtained in this research. On the other hand, men expressed being more updated about new technologies (57.89%) compared to women (42.11%).

Content knowledge

Content knowledge represents the knowledge that the teacher has developed in relation to the subject he/she teaches, that is, his/her mastery of the knowledge related to the subject (Koehler and Mishra, 2006), in this regard, teachers perceive themselves at a high level (M=4.57). These results coincide with those recorded by Roig-Vila and Flores (2014), who found in their research that teachers have high levels of knowledge about the contents of the subject they teach. This is logical when considering that most teachers at the higher level are professionals hired to teach due to their experience in the area. In the case of the School of Accounting and Administration, 37.6% of the teachers have initial training in public accounting.

Pedagogical knowledge

This type of knowledge refers to knowledge about teaching and learning processes and methods. The teacher understands how students construct their knowledge and acquire skills to learn (Koehler *et al.*, 2015). The participating teachers obtained a high level of pedagogical knowledge (M=4.47), they are able to evaluate students' performance (M=4.65), as well as to recognize both the successes and mistakes that students usually make when trying to understand the subject contents. Teachers reflect a high level of pedagogical knowledge when it comes to organizing playful activities and maintaining classroom dynamics (M=4.54), and adapting their teaching practice to the comprehension needs of their students (M=4.50). The above contrasts with the results of Lee and Kim (2014) and by Ryymin *et al.*, (2008) who concluded that teachers lack pedagogical knowledge, which hinders the integration of TPACK.

Of the total sample, only one teacher claimed not to know how to evaluate the performance of their students in the classroom, while two of them admitted not knowing how to adapt their teaching style to the needs of the students, whether or not they understand the topics covered in the subject.

Pedagogical knowledge of content

This type of knowledge is consistent with the idea of Shulman, who in 1986 pointed out that this knowledge is the transformation that the teacher makes when interpreting the content of the subject he/she teaches and finds different ways to represent it, adapting it according to the materials and tools he/she has and according to the previous knowledge of his/her students (Koehler *et al.*, 2015).

The results found show that in sum, more than 88% of the teachers stated that they were able to effectively choose diverse and effective approaches to guide their students' learning and support them in understanding the content of the topics of the subject they teach. It is worth mentioning that no teacher considers himself/herself incapable of knowing how to support his/her students in understanding the content of his/her subject.

Technological knowledge of content

According to Koehler *et al.* (2015), this knowledge involves how technology and content are related, influencing or constraining each other. It is necessary for teachers to understand which technologies are most appropriate for approaching the content of the subject they teach.

In the TPACK survey, 82% of teachers indicated that they "agree" or "strongly agree" that they have knowledge about the technological tools they can use to develop the educational content of their subjects. Of this percentage, 54.35% of those who selected "strongly agree" were men, while 45.65% were women. This places men with 8.7% more technological knowledge of the content of the subject they teach as compared to women.

Technological pedagogical knowledge

This knowledge involves understanding the pedagogical possibilities and limitations of technological tools in relation to appropriate strategies for teaching. Teachers must develop skills to use technology for pedagogical purposes, even when these tools have not been designed for that purpose (Koehler *et al.*, 2015).

The results revealed that 89.6% of teachers chose the options "agree" and "strongly agree" when asked about the adoption of critical thinking and detailed reflection as a result of their teacher training. On the other hand, 58.4% of teachers stated that their training can influence the way in which

technology impacts the didactic strategies they employ in their teaching practice.

Technopedagogical content knowledge

As Koehler *et al.* (2015) indicate, this knowledge arises from an understanding of technological, pedagogical, and content dimensions; however, it goes beyond these concepts, as it requires that they be merged to generate an effective foundation for teaching with technology.

Among the teachers surveyed for this research, 77.6% stated that they "agree" and "strongly agree" in having the necessary knowledge and skills to teach using a combination of didactic strategies, technology and computer software, while 88% expressed having the ability to adequately integrate technological tools, content and pedagogical strategies to design learning activities in their teaching work. This level of knowledge is high (M=4.14), which implies that teachers have the necessary capacity to choose technologies, design learning strategies and teach classes by effectively combining pedagogy, technology and subject content, in addition to having the ability to motivate other teachers to do the same.

It is necessary to highlight that the highest levels correspond to the dimensions of knowledge of subject content (M=4.57) and pedagogical knowledge (M=4.47). On the other hand, the dimension of technological knowledge is at the lowest level (M=3.97); however, if observed from a general perspective, all dimensions are above average. Based on the results obtained, it can be affirmed that teachers possess a high level of conceptual knowledge in relation to technology integration, according to the information obtained from the TPACK survey applied to UAS university teachers.

DISCUSSION

The incorporation of technologies into the educational environment, in the sense that teachers use them to carry out pedagogical activities in their practice, is not an automatic process. The behavior of technological tools will depend largely on what the teacher can do with them, on his or her ability to innovate in the creation of didactic strategies and on his or her ability to adapt them to the educational challenges presented (Cabero *et al.*, 2020; Cabero *et al.*, 2014; Sunkel *et al.*, 2014).

Technology integration has been categorized into five approaches: 1) software-focused initiatives, 2) sample classes and projects, 3) technology-based education reform efforts, 4) structured workshops, and 5) technology-focused teacher training courses (Harris *et al.*, 2009).

What is interesting about these approaches is that, despite their differences, they share the characteristic of having organized their efforts in terms of technologies, rather than the curricular needs of students; however, these so-called technocentric[1] approaches pay little attention to pedagogical and content knowledge. Moreover, they overlook the various forms of disciplinary knowledge and the diversity of appropriate pedagogical strategies for teaching, and fail to consider that the introduction of technological tools in educational spaces has profound implications in the pedagogical and content areas (Harris *et al*., 2009).

Beyond the integration of ICT in the classroom, teachers must be able to combine the use of technology with their vision of teaching and learning. Those teachers who achieve this will be able to use technology to boost the learning process in their students and avoid using other practices with more modern tools or technologies. It should be kept in mind that teaching is constantly evolving, as are technological tools (Kluzer *et al*., 2018).

Kohler and Mishra (2006) highlight that technological integration takes place when teachers' knowledge about the content of the subject they teach, pedagogical knowledge, and knowledge about the use of technology are at the same level of importance, and argue that effective technological integration occurs when this knowledge is coordinated and integrated with each other.

Technological integration models

Based on the previous paragraphs, new models have emerged that abandon technocentrism and encourage teachers to integrate technology in the development of their activities. Among these approaches are the following:

(a) TEG Model (technology, education and management)

This model has been developed by the research team of DuocUC, a higher education institution in Chile, and is oriented towards the generation of strategies for e-learning and competency-based curriculum development. Its emphasis is on the design and validation of a model that integrates technological, educational and management tools (Herrera, 2001).

b) TIM Model (Arizona Technology Integration Matrix)

This model is proposed by the instructional technology center at the University of Florida and later adapted by the K12[2] center in Arizona. It uses a double-entry table to assess the level of integration of technology

[1] The term technocentric was defined by Papert in 1987 with the purpose of pointing out that the main focus is on technology.
[2] K12, the term used in the United States to refer to students in kindergarten through twelfth grade, is equivalent to pre-college levels.

tools by elementary school teachers. The model considers two approaches: the first determines the levels of technology integration into the curriculum, which consist of entry, adoption, adaptation, infusion, and transformation; the second establishes the characteristics of the learning environment, classifying them as active, collaborative, constructive, authentic, and goal-directed. Both dimensions are perceived in the model of Cendoya and Martino (2015).

c) SAMR Model (Substitution, Augmentation, Modification and Redefinition)

Developed by Rubén D. Puentedura, this model aims to support teachers in improving the integration of technological tools in the design of their activities. It is based on two stages: improvement, whose elements are substitution and augmentation; and transformation, which encompasses the levels of modification and redefinition (Cendoya and Martino, 2015).

d) TPACK Model (Technological Pedagogical Content Knowledge)

This model was developed in 2005 by Mathew Kohler and Punya Mishra, teachers and researchers at Michigan State University in the United States. This paradigm is based on Shulman's contributions made in 1986 and 1987 on pedagogical content knowledge (PCK), to which the authors add the component of technological knowledge (TK), as part of the knowledge that the teacher must possess in view of the emergence and incorporation of technologies in education (Koehler and Mishra, 2005).

This model of technological integration was adopted in this research, since it clearly details the knowledge that the teacher has about the subject he/she teaches, the didactics he/she uses and the technological tools he/she uses.

In order to have a better understanding of the model proposed by Mishra and Kohler, its components and characteristics will be reviewed. The TPACK model is the result of the intersections between the three main types of knowledge: pedagogical (PK), technological (TK) and content (CK), and the interrelationships they generate: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPACK) (Koehler and Mishra, 2009). The seven components of the TPACK model as explained by Cabero *et al.* (2014), Koehler and Mishra (2006), Koehler *et al.* (2013), and Koehler *et al.* (2015) are described below.

> 1) Technological knowledge (TK). This is the understanding that teachers have of the various technologies that they can use to develop their teaching activities, from the most traditional to the newest, such as Web 2.0. The teacher needs to understand

technology in order to be able to apply it both in his work and in his daily life. He/she must be able to identify when technology benefits or hinders achieving a goal, adapt to constant changes and perform various tasks using technological tools. It is essential that the teacher recognizes that technological knowledge is in continuous development, more than pedagogical and content knowledge, and that his or her knowledge of technology goes beyond computer literacy, since knowing how to use technology is not the same as understanding how to teach with it (Koehler and Mishra, 2006).

It is important to have the ability to learn and adapt to new technological tools, as well as to understand technology and how to work with it. Technological knowledge includes understanding the operating system and the physical elements of the computer (hardware), as well as the ability to create and save documents. It also includes the ability to install, uninstall and use software tools such as spreadsheets, web browsers and email, as well as install and uninstall peripheral devices such as printers, speakers and scanners.

2) Technological pedagogical knowledge (TPK). They are the pedagogical activities that a teacher can carry out making use of technological tools suitable for a specific task or activity. The teacher must have the necessary ability to know the limitations and pedagogical possibilities of the technological tools and the disciplinary contexts with which they work, in addition to understanding how teaching changes when these tools are used, reconfigure them for pedagogical purposes and develop a creative flexibility to reformulate the technical purpose of technologies in education, that is, give an educational use to technologies even if they have not been created for that purpose. The technologies used insert the TPK into the KP.

3) Technological content knowledge (TCK). It is the teacher's understanding of how technology and content relate and influence each other. The teacher must be able to identify how technology can facilitate and create new representations for subject-specific content, and to understand how content changes to technology and vice versa. The aim is for the teacher to know how to select the technological tools and resources that will help the students to learn particular aspects of the contents and curricular programs.

4) Content knowledge (CK). It refers to the knowledge of the teacher regarding the subject taught. It includes general and specific objectives, concepts, theories, ideas, practices, approaches and procedures to develop this knowledge. For this, you must know and understand in depth the nature of content knowledge and investigate in different fields.

5) Pedagogical knowledge (PK). It is defined as the teacher's knowledge of pedagogical activities, teaching processes and methods and their relationship with educational purposes, regardless of the subject they teach. The teacher must have the ability to apply cognitive, social and learning development theories, which implies having knowledge about the planning of the classes, the techniques or methods used, values, the formation of working groups and the evaluation of learning. Another important aspect is that you must understand how the student learns, acquires and develops cognitive skills.

6) Pedagogical content knowledge (PCK). This knowledge is similar to the idea developed by Shulman regarding the transformation of content knowledge for teaching, which is generated from the interpretation of content and the various ways of representing it, tailor materials and resources, as well as students' ideas and background knowledge. This representation is related to the formulation of concepts, pedagogical techniques and knowledge to identify which contents are simple or complex to assimilate by students. The teacher has the ability to explain a subject and considers the particularities of the students to promote their learning, in addition to identifying and correcting possible misconceptions that may arise.

7) Technological pedagogical content knowledge (TPACK). It is the result of the interaction between pedagogical, content and technological knowledge, which differs from the individual knowledge of each component, as it requires understanding concepts and using pedagogical and technological skills for content teaching. The teacher coordinates the knowledge of the subject and carries out specific activities using technological tools to facilitate the students' learning. As it becomes "transparent", the TPACK becomes PCK (Cabero *et al.*, 2014).

The teacher creates the TPACK by integrating the technological, pedagogical, content and contexts in which they are presented. Although each situation is unique, there may be different technological solutions depending on the subject and the skill of the teacher to move between the three knowledge and their interactions in the educational environment in which it is developed. Teaching with technology requires continuously creating, maintaining and restoring dynamics of balance between all components, which requires constant updating (Koehler *et al.*, 2015).

CONCLUSIONS

This research has identified the most important elements in the inclusion of technological tools in teaching practice and training in the seven dimensions of knowledge. According to the results obtained in this research, in relation to the level of technological knowledge expressed by university teachers, contrary to what was expected, this level was high (M=3.97)However, no empirical evidence was obtained to support the specific hypothesis that the level of technological integration of teachers is mainly affected by a low level (M 2.3) in the dimension of technological knowledge. The above hypothesis is therefore not confirmed.

It is important to determine the level of technological integration based on the conceptual knowledge that university teachers possess in the dimensions that make up the TPACK model; However, this integration should also be reflected in the planning and implementation of various technology education activities.

It is concluded that the teaching activities promoting disciplinary learning are related to the level of technological integration according to the TPACK model, which proves the hypothesis of this research.

Like any research work, this study could benefit from other approaches. For example, it would be valuable to incorporate direct observation of educational practices involving technologies in the classroom, in addition to examining in greater depth the working conditions of teachers as regards the availability of the necessary technological tools in the classroom.

It is essential to carry out several continuous refresher courses, oriented to the real needs of teachers. These courses should focus not only on the integration of technological knowledge, but also on pedagogical knowledge, especially on strategies focused on learning, and on mastering disciplinary content. In this way, teachers will be able to continue advancing in the integration of technology in their educational practice.

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