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TPACK MODEL AND DIGITAL COMPETENCIES: IMPACT ON TEACHING PRACTICE IN ECUADORIAN SCHOOL CONTEXTS

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Abstract

The general objective of this study was to demonstrate the effect of the TPACK model on the development of digital skills among teachers at a private school in the Daule canton of Ecuador, during 2024. The research used a quantitative approach, with a quasi-experimental pretest-posttest design with control and experimental groups. The population consisted of 128 teachers, from which a non-probabilistic sample of 70 participants was chosen, equally divided into two groups. For data collection, a verified questionnaire was used that reviewed three aspects of digital skills: instrumental, didactic, and communicative. The results showed that, after implementing a program to improve digital skills based on TPACK, the experimental group showed significant improvements in all areas of living. 91.43% of the teachers in the experimental group reached a high level of digital skills, compared to only 25.71% of the control group. A significant increase was also noted in the instrumental, didactic, and communicative areas, demonstrating improved use, reflection, and education with technology. It was concluded that using the TPACK model has a positive impact on the overall growth of teachers' digital skills, helping them better integrate technological tools with lessons. These data support the idea that it is beneficial to include the model in ongoing courses for teachers; courses that seek to address the needs of today's education environment.

Keywords: educational technology, professional competence, teacher training, pedagogical innovation.

INTRODUCTION

Digital skills are necessary for effective use of technology in personal and work situations. However, teachers face many challenges in improving them, such as insufficient basic instruction, a reluctance to change how they teach, and a lack of technological infrastructure. These gaps negatively impact the quality of learning and do not adequately prepare students for a work environment that uses the internet. Therefore, organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2021) and the Organization for Economic Cooperation and Development (OECD, 2020) have pointed out that improving teacher training in digital skills is key to achieving the Sustainable Development Goals (SDGs), especially number four on educational quality.

In this scenario, the Technological, Pedagogical and Content Knowledge model, better known as the TPACK model, appears as a good option for using technology in teaching in a real way (Paidicán and Arredondo, 2023). In this sense, several investigations around the world and the country show that TPACK improves the way of teaching, helps develop evaluation methods, and supports work among students. Even so, the levels of digital skills among teachers in Latin America continue to present low levels in their development, which makes it more important to have constant classes to teach them.

In this context, this research was carried out at a private educational institution in Daule, Ecuador. The integration of technology in the 2024 academic year revealed problems with teachers' use of digital tools, which harmed learning motivation and results. Given this problem, the aim is to understand the effect of the TPACK model on improving teachers' skills in three areas: digital management, teaching, and communication.

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The information was based on the connectivist learning method, viewing technology as a tool for creating knowledge networks (Camacho-Herrera et al., 2023). Thus, this work was justified from a practical, methodological, and social perspective by presenting a teaching model that can be used in other educational settings. Finally, theoretical and real-life cases were reviewed that confirm the effectiveness of the TPACK model in improving digital teaching tools, demonstrating its potential as a way to improve education in digital spaces.

At the global level, several studies support the important role of the TPACK model as a key teaching aid for teachers. Paidicán and Arredondo (2023) found that, although the use of the TPACK model has not been widely investigated in Ibero-American research, there is more interest in finding how to use it in areas where various knowledge sources come together. In turn, Iskandar et al. (2021) showed that strong training based on TPACK and the emotional quotient better develops teachers' teaching skills, increasing their effectiveness and the quality of what they teach. On the other hand, in Namibia, Nepembe and Simuja (2023) showed that teachers' experience and aptitude have a direct effect on the use of the TPACK framework, which shows the need to always learn for better technological usability. Similarly, studies such as those conducted by Silva et al. (2021) and Flores (2024) emphasize that, although teachers consider how important it is to know how to teach and know about a subject, it is therefore very necessary to improve the technological side to have a good way of leading classes. These findings agree that the TPACK model provides a solid and flexible foundation to address the problems faced by online learning.

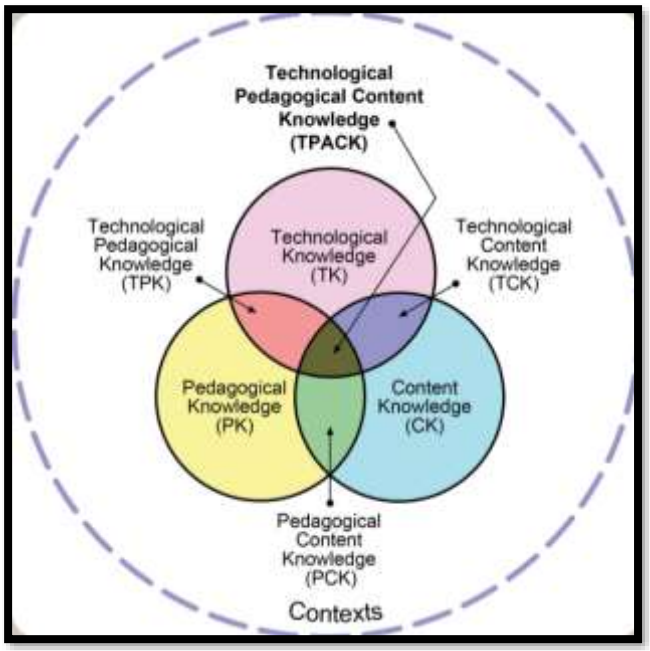
Meanwhile, at the national level, research has shown the usefulness of the TPACK model in the Ecuadorian context. Lema (2021) indicated how well this model reinforces active learning in science, using digital tools, with clear numbers that prove its usefulness in the classroom. On the other hand, in the area of foreign languages, Torres et al. (2021) used the model to teach English, finding that teachers with more experience perform better in the teaching and technology aspects of the model.

Rodríguez and Acurio (2021) analyzed the use of TPACK in teaching mathematics with active methods, emphasizing its ability to improve learning processes with new technologies. These studies agree that teachers must be trained in digital skills using frameworks such as TPACK, which help teachers' professional growth and deliver quality education in both public and private sectors of the country.

This research seeks to answer this question: How does the TPACK model affect the growth of the digital skills of educational staff at a private institution in Daule, Ecuador, in 2024? To answer this question, the general objective was: To demonstrate the impact of the TPACK model on the digital skills of teachers at an educational institution in Daule, Ecuador, in 2024, in order to show how integrating technological, pedagogical, and subject-area knowledge influences the improvement of teachers' digital skills, necessary to manage the challenges of current teaching. The TPACK model appears as an improvement of Shulman's (1987) proposal on Pedagogical Content Knowledge (PCK). Koehler et al., (2013) expand this proposal by adding knowledge of technology, highlighting that teachers must not only know a lot about their discipline and ways of teaching, but they must also use technological tools to improve teaching and learning.

Now, according to Mishra & Koehler (2006), the TPACK model has seven elements: knowledge of what is taught (CK), knowledge about how to teach (PK), knowledge about technology (TK), knowledge about how to teach what is taught (PCK), knowledge about how to use technology with what is taught (TCK), knowledge about how to use technology to teach (TPK) and knowing technology, pedagogy and content (TPACK). This last element shows how the three main parts are well integrated, helping to teach in a way that is clear to understand. This explanation of the elements of the TPACK Model can be seen in Figure 1, taken from the book by Mishra & Koehler (2006).

Figure 1 Elements of the TPACK Model



Note: Mishra & Koehler (2006)

The existing literature underscores how effective the TPACK model is in helping teachers gain digital skills (Salas-Rueda, 2018). In this sense, studies conducted in Mexico by Hernández et al. (2024) and in Colombia by Monsalve-Suárez et al. (2024) show the same thing: this model improves lesson planning, the design of engaging materials, and the use of digital aids to monitor progress. Furthermore, it increases students' thinking skills, imagination, and desire to learn.

In Ecuador, research such as that by Suárez et al. (2019) and Yunga et al. (2024) has demonstrated the benefits of TPACK in teaching, especially in the area of working with numbers. This work shows that teachers using the TPACK method can integrate electronic tools well with the topics they must cover, improving students' grades and creating a classroom environment where everyone participates and works together.

Therefore, the TPACK model is seen as a clear and useful guide to look at and help develop teachers' digital skills, allowing them to use ICT in a way that is good for teaching and adapts to the needs of the 21st century.

It should be noted that the TPACK model, initially suggested by Mishra and Koehler (2006), depends on the combined knowledge of three types that each teacher needs to teach well in these digital times: knowledge about their discipline (CK), knowledge about how to teach (KH), and knowledge about technology (KT). This combination is based on several ideas about learning and using technology that give strength to its use.

Along these lines, constructivism, especially the views of Piaget (1972) and Vygotsky (1978), supports the TPACK model because it believes that learning is an action where the individual generates their own knowledge by interacting with their world. TPACK proposes a way of teaching that puts the student at the center, bringing together important topics, good ways of teaching, and technological tools that motivate students to look, work together, and construct knowledge.

An interdisciplinary theoretical framework is what informs the TPACK model, making its use even more useful and important today. Constructivist, social, and new ideas such as connectivism, along with theories about skills and change in education, show that the mix of technology must be accompanied by careful

pedagogical thinking and up-to-date disciplinary expertise (Serrano & Pons, 2011). These academic foundations give value to TPACK as a way to professionally support teachers in digital environments.

MATERIALS AND METHODS

This research used a quantitative method with a quasi-experimental design, as it attempted to measure and observe the effect of the TPACK model on the development of digital competencies (DC) in teachers at a school in Daule. The study is classified as applied because it focuses on the causal relationship between the "parts of the TPACK model" and digital skills (Hernández, 2017). A longitudinal design allowed for the use of a pretest and posttest to observe significant changes over time, comparing an experimental group that received training based on the TPACK model with a control group that did not receive the method. The independent variable was the TPACK model, which included "how the integration of technological, didactic, and content knowledge in teaching contributes to teacher training." This training sought to improve three aspects: knowledge about the subject matter, knowledge how to teach, and knowledge about technology. Likewise, the dependent variable was digital skills, observed in three areas: instrumental, didactic, and communication. These skills were measured with a questionnaire developed by the researcher, on a five-level Likert scale, and verified by expert judgment and a Cronbach's safety number ($\alpha = 0.95$) based on what was stated by Ñaupas et al. (2018).

The sample consisted of 128 teachers from two schools: 52 from the private school and 76 from the public school. The sample was non-probabilistic and purposive, including 70 elementary and high school teachers, divided equally between the experimental and control groups. Furthermore, the criteria for integrating the sample included teachers with permanent jobs and Ecuadorian nationality, excluding those working at the initial levels or with temporary contracts. Furthermore, a structured form was used to collect the data, which analyzed digital skills before and after the intervention. This instrument, with 30 questions (10 per topic), was administered to the experimental group in two locations. The questionnaire was well validated by experts and was considered reliable. Furthermore, the strategy used allowed for comparable numbers between both groups to analyze the effects of the training.

Meanwhile, data analysis used methods that both show numbers and make connections. Thus, the Shapiro-Wilk normality test and the separate-groups t-test were used to compare before-and-after results between two groups and determine if there were significant differences. Clear standards for scientific research were followed. Furthermore, the participants' respective permission was obtained, their anonymity was maintained, and their sensitive data was safeguarded. In this way, the teachers' participation and well-being were protected by ensuring that the data obtained would only be used for educational purposes.

RESULTS

Below are the results obtained before and after the implementation of the program based on the TPACK Model:

Table 1

Level of digital skills before implementing the program.

		Pre-test			
Variable	Levels	Control		Experimental	
		fi	%	fi	%
Digital skills	Low	7	20,00%	4	11,43%
	Medium	19	54,29%	24	68,57%
	High	9	25,71%	7	20,00%
Total		35	100%	35	100%

Note: *Statistical Analysis - IBM SPSS Statistics 30.0*

Table 1 shows the results obtained from the initial test. These results show that many of the teachers in both the control group (CG) and the experimental group (EG) were at a medium level of digital skills. However, the EG had a slightly higher percentage at this level (68.57%) compared to the CG (54.29%). Furthermore, the percentage of teachers at the low level was lower in the EG (11.43%) compared to the CG (20.00%). These data show that the two groups started more or less equal before the lesson, although the EG had a small advantage by concentrating more of their time at the medium level and less at the low level.

Table 2.

Level of digital skills after the program has been implemented.

		Post-test			
Variable	Levels	Control		Experimental	
		fi	%	fi	%
Digital skills	Low	4	11,43%	0	-
	Medium	22	62,86%	3	8,57%
	High	9	25,71%	32	91,43%
Total		35	100,00%	35	100%

Note: *Statistical Analysis - IBM SPSS Statistics 30.0*

After the implementation of the digital skills improvement plan, the data shown in Table 2 show a large change in the work of the group that received the plan (GP). No teachers in this group were low in digital skills, but in the group that did not have the plan (GC), there are still four teachers (11.43%). Thus, for the medium level, the CG has 62.86% of people, while the GE only has 8.57%. It is important to note that at the high level, the GE reaches 91.43% (equal to 32 teachers), but the GC has the same percentage as before (25.71%). These results show great help in the group that had the help, unlike the group that did not receive anything, where the changes were small.

Table 3.

Level of instrumental digital skills before the intervention.

		Pre-test			
Dimension	Levels	Control		Experimental	
		fi	%	fi	%
Instrumental	Low	3	8,57%	1	2,86%
	Medium	18	51,43%	25	71,43%
	High	14	40,00%	9	25,71%
Total		35	100,00%	35	100,00%

Note: *Statistical Analysis - IBM SPSS Statistics 30.0*

Table 3 shows the results of the pretest regarding team management in digital skills. In the no-change group (CG), 8.57% of teachers were at the low level, 51.43% at the medium level, and 40% at the high level. On

the other hand, in the change group (GE), 2.86% reached the low level, 71.43% reached the medium level, and 25.71% were at the high level. These data show that, before the content, both groups had many participants at the medium level. However, the EG showed a higher proportion of people at that level, and fewer at the high levels than the CG.

Table 4.

Level of instrumental digital skills after the intervention.

		Post-test			
Dimension	Levels	Control		Experimental	
		fi	%	fi	%
Instrumental	Low	1	2,86%	0	-
	Medium	18	51,43%	4	11,43%
	High	16	45,71%	31	88,57%
Total		35	100,00%	35	100;00%

Note: *Statistical Analysis - IBM SPSS Statistics 30.0*

An examination of the information shown in Table 4 reveals the findings of the final exam on the instrumental aspect of digital skills for teachers. In the no-change group (CG), 2.86% of teachers remained at the low level, 51.43% remained at the medium level, and 45.71% reached the high level. On the other hand, in the group that tried something new (GE), no teachers were placed at the low level, 11.43% were placed at the medium level, and 88.57% reached the high level. These numbers show a significant improvement for the GE after using the program that strengthens digital skills based on the TPACK model, highlighting a significant increase in the number of teachers with a good instrumental level.

Table 5.

Level of digital teaching skills before the intervention.

		Pre-test			
Dimension	Levels	Control		Experimental	
		fi	%	fi	%
Didactics	Low	8	22,86%	5	14,29%
	Medium	18	51,43%	17	48,57%
	High	9	25,71%	13	37,14%
Total		35	100,00%	35	100,00%

Note: *Statistical Analysis - IBM SPSS Statistics 30.0*

The information given in Table 5 shows the initial situation of the groups before using the program to increase digital skills. In both cases, both the control group (CG) and the experimental group (EG) had a

large number of people at the medium level of digital skills to teach, with 51.43% in the CG and 48.57% in the EG. However, an advantage is seen at the beginning for the EG because this group had more teachers at the high level (37.14%) compared to the CG (25.71%), and fewer people at the low level (14.29% vs. 22.86%). This mix of levels shows that, although the groups started in similar conditions, the EG had a better level of digital skills to teach before the program.

Table 6.

Level of digital teaching skills after the intervention.

		Post-test			
Dimension	Levels	Control		Experimental	
		fi	%	fi	%
Didactics	Low	5	14,29%	0	-
	Medium	20	57,14%	2	5,71%
	High	10	28,57%	33	94,29%
Total		35	100,00%	35	100,00%

Note: *Statistical Analysis - IBM SPSS Statistics 30.0*

The information in Table 6 shows that after using the program to improve digital skills, the test group (GE) made significant progress in improving digital skills. Specifically, 94.29% of GE educators reached the high level, none remained at the low level, and only 5.71% remained at the medium level. The CG had a more diverse mix: 57.14% were in the middle, 28.57% reached the high level, and 14.29% remained at the low level. These numbers show that the action taken in GE was successful, as not only did the number of teachers with good work increase significantly, but all cases with a low level in this area were also eliminated.

DISCUSSION

The research verified the positive effect of the TPACK model on improving the digital skills of teachers at a private school in Daule, Ecuador. Through an informal approach, it was found that both the experienced group (EG) and the regular group (CG) had similar skill levels at the beginning. However, after using the TPACK-based teaching program, the EG showed significant improvement in their scores, highlighting a significant increase in teachers at the high CD level. In contrast, the CG did not show significant changes. Inferential numerical analyses (Student's t-test) supported these differences with a p-value of 0.000, confirming the program's effectiveness.

Comparing these results with other studies revealed similarities and differences in methods and contexts. Research such as that by Paidicán and Arredondo (2023) and Silva et al. (2021) shows little practical work on TPACK and little involvement of teachers in the digital aspect, which is different from the practical and testing approach of this study. Also, studies such as those by Iskandar et al. (2021) and Nepembe and Simuja (2023) noted improvements in teacher instruction with the TPACK model, although they used varied and qualitative methods. These comparisons strengthen the validity of this analysis and its practical contribution to the educational field.

On the other hand, the analysis of each part showed that the tool use section was the one that improved, with great progress in the Understand Group (from 3,340 to 4,340), a result that coincides with what the books read say. In the teaching part, positive changes were seen (from 3,160 to 4,322), an indicator that the TPACK model not only helps students use digital tools, but also how they are applied in class. Likewise, the communication section showed great growth (from 2,746 to 4,257), corroborating that the model can improve interaction processes and comprehensive work among teachers.

From a theoretical perspective, the results are consistent with Mayer's (2005) Cognitive Theory of Multimedia Learning and Siemens' (2004) Connectivism, fostering meaningful learning through the blending of diverse digital resources. These frameworks support the idea that a good balance between

knowledge about technology, teaching, and particular topics improves classroom learning and teacher growth. Furthermore, the increase in digital skills seen in this study demonstrates how these concepts are effectively used in a real-life classroom situation. Ultimately, the findings support the main idea and support that the TPACK model, when used with intention and a clear context, has a significant impact on improving teachers' digital skills. This proposal addresses the needs of today's technology-mediated education and provides clear evidence of how organized action can close training gaps and support teaching practices that are more equitable, functional, and in line with the Sustainable Development Goals (SDGs), especially SDG 4.

Proposal for Rural Educational Institutions based on the TPACK Model

This proposal aims to help improve the use of the TPACK model in rural schools to develop teachers' digital skills and their work through effective use of technological tools. In places like Ecuador, rural or rural schools struggle to integrate new technologies into their classrooms. These problems include poor technology infrastructure, poor communication, and poor training of teaching staff in digital skills.

Faced with this situation, the Technological Pedagogical Content Knowledge (TPACK) model, created by Mishra and Koehler in 2006, provides a comprehensive view that combines subject knowledge, pedagogical knowledge, and technology management. Therefore, its use allows teachers to plan and lead lessons supported by technology in a useful and clear manner. Using this model in rural schools would help improve teachers' work. It would also promote fairer, more inclusive and better education, in line with the rules of Sustainable Development Goal number 4 of Agenda 2030.

The overall objective of this project is to implement the TPACK model in rural settings, aiming to improve teachers' digital skills and enhance their classroom practice by using ICTs in meaningful ways. To achieve this, there are three clear points: first, to determine how well teachers currently know about technology, teaching, and their subject matter; second, to create and implement a course for their work that follows TPACK; and third, to assess and evaluate their use of teaching strategies with digital tools.

The idea will be carried out with an action research method, using a quasi-experimental design and a mixed type (qualitative and quantitative) with a long-term view. Four phases are envisioned. The first part is about the initial diagnosis, where surveys and talks with teachers will be used to determine their level of TPACK skills and find out how ready they are in the technological field in their schools. The second part includes teaching teachers, which will be through face-to-face and online workshops around the three facets of the TPACK model, emphasizing its use in rural areas. Then, in the stage of putting something into operation, teachers will plan and create teaching sequences that mix technology, pedagogy, and content, with an eye to the context. Finally, in the review and support section, we will examine teaching methods through vouchers, digital portfolios, and follow-up talks, in order to see what has been achieved and change the methods of support.

Overall, this plan aims to reduce the technology gap in the field, with teaching that focuses on improving the work of teachers, seeking transformative, contextualized, and sustainable teaching.

CONCLUSIONS

The results of the study suggest that implementing the TPACK model led to a significant and clear change in the growth of the digital skills of the group of teachers at a private school in Daule during the year 2024. Thus, the numerical test shows that 91.43% of the teachers in the experimental group reached the highest level when reviewed after the intervention. The contrast between the experimental and control groups reveals that, although they started with similar situations in the pretest, the group undergoing the intervention showed notable progress in their performance, thus supporting the formulated idea.

Regarding the instrumental dimension, the analyzed data show that training in the TPACK model brought significant changes in the use of technological tools by the experimental group. Furthermore, the increase in the mean scores, along with a smaller dispersion of the data, indicates a strengthening of technical knowledge and greater uniformity in the level of proficiency among teachers. This progress confirms that the model helps build basic skills for combining digital resources in teaching practice. Regarding teaching, it was noted that the teachers in the new group made better use of technology in preparing, developing, and measuring their classes.

The findings show not only an improvement in the ability to apply technology, but also greater firmness when using it for educational purposes. Compared to the group that did not receive the TPACK Model, the control group's performance was more uniform and stable. Finally, in terms of communication, there was significant progress in the use of the internet to communicate and work together in virtual spaces. Teachers who participated in the program greatly improved their use of websites and tools to communicate, which led to higher average grades and a smaller gap between results. These successes demonstrate a significant improvement in the way educators manage better and more active relationships in digital learning environments.

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