ISSN. 1815-7696 RNPS 2057 -- MENDIVE Vol. 20 No. 3 (July-September)
Paidican Soto, M.A., Arredondo Herrera, P.A. "Conocimientos tecnopedagógicos y disciplinares en los docentes de primaria y los factores demográficos" pp. 906-916
Available from: https://mendive.upr.edu.cu/index.php/MendiveUPR/article/view/2949

2022

MENDIVE
REVISTA DE EDUCACIÓN

Translated from the original in Spanish

Original article

Techno-pedagogical and disciplinary knowledge of primary school teachers and demographic factors

Conocimientos tecnopedagógicos y disciplinares en los docentes de primaria y los factores demográficos

Conhecimento técnico-pedagógico e disciplinar em professores do ensino fundamental e fatores demográficos

Miguel Angel Paidican Soto[1]
https://orcid.org/0000-0003-0696-054X
Pamela Alejandra Arredondo Herrera[2]
https://orcid.org/0000-0002-4888-4584

[1]University of Barcelona. Spain.
mpaidiso7@alumnes.ub.edu
[2] University of Granada. Spain
pamfergab2506@gmail.com

Received: March 6th, 2022.
Accepted: June 6th, 2022.

ABSTRACT
The integration of modern technologies is a challenge for society, and schools are no stranger to this reality, where the role of teachers is key to their adequate development. The aim is to present the results obtained from the analysis of the knowledge presented by teachers in relation to the context and components of Technology, Pedagogy and Content Knowledge. The method was based on quantitative, non-experimental and transactional aspects. Descriptive, comparative and correlational analyzes were carried out using SPSS version 26. The non-probabilistic sample consisted of 355 basic education teachers from the province of Valparaíso. The Technology, Pedagogy and Content Knowledge questionnaire adapted to the Chilean reality was used as an instrument. The results show that teachers had higher levels of pedagogical and disciplinary knowledge compared to technology teachers. Female teachers showed higher levels of knowledge in most of the Technology, Pedagogy and Content Knowledge dimensions. On the other hand, teachers from private subsidized schools and those with master's degrees showed better results in all dimensions of the Technology, Pedagogy and Content Knowledge. In addition, the existence of positive correlations between the variables studied was confirmed, highlighting those related to technological knowledge.

Keywords: knowledge of teachers; educational technology; Technology, Pedagogy and Content Knowledge; primary school teachers; teacher training; integration of technology.

RESUMEN
La integración de las nuevas tecnologías representa un reto para la sociedad y la escuela no es ajena a esta realidad, donde el rol del profesorado es clave para un desarrollo adecuado. El objetivo del presente artículo es exponer los resultados obtenidos del análisis de los conocimientos presentados por docentes, con relación al contexto y los componentes del Conocimiento Tecnológico Pedagógico del Contenido. La metodología estuvo basada en aspectos cuantitativos, no experimentales y transaccionales. Se realizaron análisis descriptivos, comparativos y correlacionales por medio SPSS, versión 26. La muestra no probabilística estuvo compuesta por 355 docentes de educación primaria de la provincia de Valparaíso. Se utilizó como instrumento el cuestionario del Conocimiento Tecnológico Pedagógico del Contenido adaptado a la realidad chilena. Los resultados dejan de manifiesto que los docentes presentaron mayores conocimientos pedagógicos y disciplinares en comparación con los tecnológicos. Las docentes mujeres exhibieron mayores niveles de conocimientos en la mayoría de las dimensiones del Conocimiento Tecnológico Pedagógico del Contenido. Por su parte, los docentes de colegios particulares subvencionados y con formación de magister, mostraron mejores resultados en todas las dimensiones del Conocimiento Tecnológico Pedagógico del Contenido. Además, se confirmó la existencia de correlaciones positivas entre las variables estudiadas, destacando las relacionadas con el conocimiento tecnológico.

Palabras clave: conocimiento de los profesores; tecnología educativa; Conocimiento Tecnológico Pedagógico del Contenido; docentes de primaria; formación del profesorado; integración de la tecnología.

RESUMO
A integração das novas tecnologias representa um desafio para a sociedade e a escola não está alheia a esta realidade, onde o papel do professor é fundamental para um desenvolvimento adequado. O objetivo deste artigo é expor os resultados obtidos a partir da análise do conhecimento apresentado pelos professores, em relação ao contexto e aos componentes do Conhecimento Tecnológico Pedagógico do Conteúdo. A metodologia foi baseada em aspectos quantitativos, não experimentais e transacionais. As análises descritivas, comparativas e correlacionais foram realizadas no SPSS, versão 26. A amostra não probabilística foi composta por 355 professores primários da província de Valparaíso. Utilizou-se como instrumento o questionário de Conhecimento Tecnológico Pedagógico de Conteúdo adaptado à realidade chilena. Os resultados mostram que os professores apresentaram maior conhecimento pedagógico e disciplinar em relação aos tecnológicos. As professoras apresentaram níveis mais elevados de conhecimento na maioria das dimensões do Conhecimento Pedagógico Tecnológico do Conteúdo. Por sua vez, professores de escolas particulares subsidiadas com mestrado apresentaram melhores resultados em toda as dimensões do Conhecimento Tecnológico Pedagógico do Conteúdo. Além disso, confirmou-se a existência de correlações positivas entre as variáveis estudadas, com destaque para aquelas relacionadas ao conhecimento tecnológico.

Palavras-chave: saberes docentes; Tecnologia educativa; Conhecimento Tecnológico Pedagógico do Conteúdo; professores primários; treinamento de professor; integração de tecnologia.

INTRODUCTION

The current educational processes require structural changes, an example of which is represented by the incorporation of new educational models. The model of Pedagogical Technological Knowledge of Contents or Technology, Pedagogy and Content Knowledge (TPACK), emerged in 2006. Mishra and Koehler's proposal states that teachers must acquire different knowledge related to content, pedagogy and new technologies. It is worth mentioning that the interaction of the three central dimensions allows us to identify four other dimensions (see Figure 1).

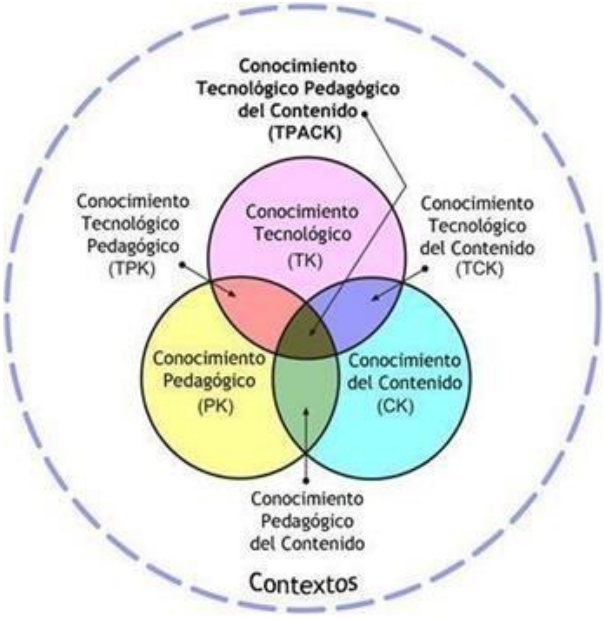

Fig. 1 - Illustration of the Technological Knowledge of Pedagogical Contents (TPACK) *Note:* Illustration from (TPACK) (Source: http://tpack.org)

The sub dimensions that make up TPACK can be identified and defined as follows:

1) Technological Knowledge (TK): these are the skills required to use Information and Communications Technology (ICT) tools such as: computers, projectors, cameras, digital videos, blackboards, the Internet and the skills to use different software programs (Koehler *et al*., 2014; Munyengabe *et al.*, 2017).

2) Content Knowledge (CK): These are skills related to the content to be taught. It should be noted that the teaching and learning processes are favored to the extent that teachers present knowledge in meaningful contexts (Mishra and Koehler, 2006; Munyengabe *et al.*, 2017).

3) Pedagogical Knowledge (PC): teachers need to have knowledge about teaching-learning processes, which should include classroom management, planning and evaluation of teaching-learning processes (Munyengabe*et al.*, 2017; Schmidt *et al.*, 2009).

4) Pedagogical Content Knowledge (PCK): occurs at the intersection of CK and PK; this is how the PCK prepares the CK in the teaching process (Munyengabe *et al.*, 2017; Koelher *et al.*, 2014).

5) Technological Content Knowledge (TCK): the result of the combination of the TK and CK; the TCK relates how technology displays specific content (Koelher *et al.* , 2014 ; Munyengabe *et al.* , 2017 ; Schmidt *et al.* , 2009).

6) Technological Pedagogical Knowledge (TPK): the result of the combination of the TK and PK refers to the TPK; this knowledge refers to how the various technologies can be used and the way in which teachers deliver the content (Mishra & Koehler, 2006; Munyengabe *et al.*, 2017; Schmidt *et al.*, 2009).

7) Technological Pedagogical Content Knowledge (TPACK): corresponds to the result of the intersection of the CK, PK and TK, which represents the knowledge that teachers must possess to integrate ICT in the teaching and learning process (Koehler *et al.*,

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2014; Munyengabe *et al.*, 2017; Schmidt *et al.*, 2009).

The greatest development of TPACK is in Anglo-Saxon, Asian, Australian and some European countries (Lee, H. *et al.*, 2022). In the Paidicán (2022) literature review, whose objective was to analyze the scientific literature related to TPACK in primary education, only 19 articles were identified, representing 3.05% of the total documents. It should be noted that none of the studies is carried out in Chile.

Added to the above is the lack of studies that indicate the relationship between the dimensions of the TPACK with demographic factors, such as gender, the administrative dependencies of schools and teacher training.

This article aims to present the results of the analysis of the knowledge presented by teachers in relation to the context and the components of the TPACK. For this it is necessary to describe, compare and relate the results with the research variables.

MATERIALS AND METHODS

The research was carried out through a quantitative, non-experimental, descriptive, comparative and correlational design. The sample was selected for convenience or intentional. The sample consisted of 355 primary school teachers from the province of Valparaíso, in the communes of Viña del Mar, Quilpué, Villa Alemana and Algarrobo. Teachers who work in Municipalized Schools (EM) and Subsidized Private Schools (CPS) were considered. Regarding the teaching staff, it is made up of 248 women (69.9%) and 107 men (30.1%). Regarding the administrative dependency of teachers, 182 (51.2%) correspond to EM and 173 (48.8%) to CPS. When referring to the academic degree of the teaching staff, 313 have a bachelor's degree (88.2%) and 42 have a master's degree (11.8%).

The instrument used is the TPACK questionnaire, adapted and validated for the Chilean reality by Paidican (2019), whose reliability according to Cronbach `s Alpha coefficient is 0.948. The questionnaire is made up of 40 items on a five-point Likert scale: Strongly disagree (1), Disagree (2), Neither disagree nor agree (3), Agree (4) and Strongly agree (5); they are related to the central dimensions and the respective interactions that make up the TPACK model.

1. Technological Knowledge (TK): 7 items

2. Content Knowledge (CK): 7 items.

3. Pedagogical Knowledge (PK): 8 items.

4. Pedagogical Content Knowledge (PCK): 3 items

5. Technological Content Knowledge (TCK): 3 items

6. Technological Pedagogical Knowledge (TPK): 5 items

7. Technological Pedagogical Content Knowledge (TPACK): 7 items

The questionnaire distribution procedure was carried out in printed and electronic format through *Google Forms* , between the months of November 2019 and March 2020.

Regarding the statistical analysis, first, a descriptive analysis of the data was performed. Second, the predominance of gender in the TPACK subdimensions was analyzed through the t-means contrast test for independent samples. Third, to establish the relationship between the different variables, Pearson's linear coefficient was used. The preparation, organization and analysis of the data was developed using the

statistical package Statistical Package from Social Sciences (SPPS Statistics), version 26 for Windows.

RESULTS

Internal consistency analysis was performed using Cronbach's alpha test, obtaining high reliability, similar to that obtained by Paidican (2019).

Descriptive analysis of the TPACK model

The study of the subdimensions that make up TPACK was carried out and the arithmetic mean, standard deviation and ranking statistics were considered (see Table 1). In addition, all the items that make up the TPACK, expressed in Table 2, were analyzed.

Table 1- Means, standard deviation and ranking of TPACK knowledge.

Types of Knowledge	Half	Standard deviation	Ranking
Technological Knowledge (TK)	3.57	,796	7
Content Knowledge (CK)	4.11	,716	2
Pedagogical Knowledge (PK)	4.28	,724	1
Pedagogical Content Knowledge (PCK)	4.02	,793	3
Technological Content Knowledge (TCK)	3.73	,836	6
Technological Pedagogical Knowledge (TPK)	3.90	,766	4
Technological Pedagogical Content Knowledge (TPACK)	3.87	,878	5
TOTAL	3.98	.643	

Table 1 shows that the global average of the TPACK questionnaire is (M Total=3.98; SD=0.643). The highest values were obtained in PK (M total=4.28 & SD= 0.71), followed by CK (M total=4.11; SD=0.72). For its part, TK presented the lowest arithmetic mean (total M=3.57 & SD=0.79).

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Table 2- Means and standard deviation of all TPACK items.

items	Half	Standard deviation
1.Technological Knowledge (TK)		
1.1 I know how to solve my technical problems with ICT	3,77	1,015
1.2 I assimilate ICT knowledge easily	3,92	,935
1.3 I keep up to date on the most important ICT	3,63	,971
1.4 I often play games and experiment with the use of ICT	3,35	1,065
1.5 I know many different ICT resources and tools	3,40	1,002
1.6 I have the technical knowledge I need to use the TIC	3,55	1,036
1.7 I have had enough opportunities to work with the different ICT resources and tools	3,36	1,074
2. Content Knowledge (CK)		
2.1 I have sufficient knowledge about my own discipline and how it is taught	4,17	,890
2.2 I have sufficient knowledge of the current *curriculum* of my discipline and the use of curricular instruments	4,20	,816
2.3 I have the ability to design, plan and implement learning experiences in my own discipline	4,32	,838
2.4 I know how to improve my students' reading comprehension so that they are frequent and thoughtful readers	4,01	,838
2.5 I know how to enhance the understanding and taste for reading literary texts in my students	4,01	,897
2.6 I understand the importance and I know how to promote the understanding of multimodal texts in my students	4,01	,913
2.7 I know how to stimulate quality written and oral production in my students	4,01	,944
3. Pedagogical Knowledge (PK)		
3.1 I know my students and I know how they learn	4,26	,936
3.2 I am prepared to promote the personal and social development of my students	4,38	,842
3.3 I know how to design and implement learning strategies, appropriate to the learning objectives and according to the context	4,26	,837
3.4 I am prepared to manage the class and create an appropriate environment for learning according to its context	4,34	,869
3.5 I know and apply evaluation methods to observe the progress of my students and use the results to provide feedback on learning.	4,18	,916
3.6 I know how school culture is generated	4,11	,811

3.7 I am prepared to deal with diversity and promote integration in the classroom	4,12	,939
3.8 I am aware that I must learn and reflect continuously	4,61	,815
4. Pedagogical Content Knowledge (PCK)		
4.1 I can select teaching approaches effectively to guide students' thinking and learning in reading	4,03	,825
4.2 I can select teaching approaches effectively to guide students' thinking and learning in writing	3,93	,893
4.3 I can select teaching approaches effectively to guide student thinking and learning in my own discipline	4,11	,849
5. Technological Content Knowledge (TCK)		
5.1 I know technologies that I can use to understand and elaborate content about reading	3,70	,929
5.2 I know technologies that I can use to understand and elaborate content on writing	3,65	,886
5.3 I know technologies that I can use to understand and create content about my own discipline	3,86	,879
6. Technological Pedagogical Knowledge (TPK)		
I know how to select technologies that improve approaches teachers for a class	3,76	,883
6.2 I know how to select technologies that improve student learning in a class	3,79	,862
6.3 My training as a teacher has made me think more carefully about how ICT can influence the teaching approaches, I use in the classroom	4,04	,903
6.4 I adopt critical thinking about how to use the ICT in the classroom	3,99	,974
6.5 I can adapt the use of ICT on which I am learning in the different teaching activities	3,90	,911
7. Technological Pedagogical Content Knowledge (TPACK)		
7.1 I can teach classes that adequately combine reading, the use of ICT and teaching approaches	3,82	1,048
7.2 I can teach classes that adequately combine my own discipline, the use of ICT and teaching approaches	3,80	1,064
7.3 I can teach classes that adequately combine my own discipline, the use of ICT and teaching approaches	3,95	,917
7.4 I know how to select the ICTs to use in the classroom that improve the content I teach, the way it is taught and what the students learn	3,91	,952
7.5 I know how to use my teaching materials and resources for the classroom, as well as the strategies that combine content, ICT and teaching approaches that I have learned about	3,89	,957
7.6 I can guide and help other people to coordinate the use of content, ICT and teaching approaches in the educational unit where I work	3,80	,994
7.7 I can select the ICTs that improve the content of the classes.	3,94	,987

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In relation to the results of table 2, it was observed that the means are between 3.35 (item 1.4) and 4.61 (item 3.8), values that are higher than the mean of the instrument (M total =2.5). In addition, the items that presented the highest scores mostly correspond to the PK sub dimension : (item 3.8; M total=4.61) "I am aware that I must learn and reflect continuously"; (item 3.2; M total=4.38) "I am prepared to promote the personal and social development of my students"; (item 3.4; M total=4.34) "I am prepared to manage the class and create an appropriate environment for learning according to its context"; (item 2.3; M total=4.32) "I have the ability to design, plan and implement learning experiences in my own discipline"; (item 3.1; M total=4.26) "I know my students and how they learn" and (item 3.3: M total= 4.26) "I know how to design and implement learning strategies, appropriate to the learning objectives and according to the context.

Regarding the items with the lowest averages, all were from the TK sub dimension : (item 1.4; M total=3.35) "I often play and do tests with the use of ICT"; (item 1.5; M total=3.40) "I know many different ICT resources and tools"; (item 1.7; M total 3.36) "I have had enough opportunities to work with the different ICT resources and tools"; (item 1.6; M total=3.55) "I have the technical knowledge I need to use ICT" and (item 1.3; M total=3.63) "I keep up to date on the most important ICTs" .

Comparative analysis according to gender, administrative dependency and academic degree

Descriptive analyzes of the arithmetic means of the TPACK subdimensions were carried out, in such a way that the possible differences according to variables (gender,

administrative dependency and academic degree) could be studied. In addition, t-tests for independent samples were performed.

The t-test for our independents was performed to compare the TPACK subdimensions in women and men. Statistically significant differences appeared in Content Knowledge (CK) between women (M= 4.16; SD= 0.709) and women (M= 3.97; SD= 0.72); t (353) = 2.429, p= 0.016. The results indicated that the women presented a greater knowledge of their own discipline than the men. In the rest of the TPACK subdimensions, they did not present significant statistical differences.

Table 3- Means, standard deviation and t-test for independent samples according to gender.

Factors	Women		Men		Test t	
Model TPACK	M	SD	M	SD	T(353)	p
TK	3,54	0,79	3,63	0,79	-,931	0,353
CK	4,16	0,70	3,97	0,72	2,429	0,016
PK	4,30	0,76	4,25	0,62	0,551	0,582
PCK	4,02	0,85	4,01	0,62	0,060	0,952
TCK	3,75	0,83	3,68	0,83	0,706	0,481
TPK	3,90	0,79	3,88	0,68	0,162	0.871
TPACK	3,91	0,92	3,79	0,75	1,195	0,233

The TPACK sub dimensions and the administrative dependency where the teachers work was compared. Statistically significant differences were exhibited in Pedagogical Content Knowledge (PCK) by CPS teachers (M= 4.17; SD= 0.67); t(355) = -3.480, p= 0.001. The result proposes that the CPS teachers presented a higher PCK, therefore, they tend to favor the learning of the students' content, compared to the EM teachers. The rest of the TPACK sub dimensions did not present significant statistical differences.

Table 4- Means, standard deviation and t-test for independent samples according to administrative dependency

	E. Municipalized		Part. Subsidized		t-test	
TPACK Model	M	SD	M	SD	t (355)	P
TK	3.49	0.73	3.65	0.84	-1,940	0.053
CK	4.13	0.73	4.08	0.69	0.761	0.447
station	4.22	0.79	4.34	0.64	-1,571	0.117
TCK	3.88	0.87	4.17	0.67	-3,480	0.001
PCK	3.65	0.79	3.82	0.87	-1,954	0.051
TPK	3.89	0.81	3.91	0.70	-0.237	0.813
TPACK	3.82	0.90	3.92	0.84	-1,081	0.280

The TPACK sub dimensions and the academic degree of the teachers were compared. There were statistically significant differences in Technological Knowledge (TK) in teachers with a master's degree (M= 3.82; SD= 0.82); t (355) = 2.199, p= 0.029. The result suggests that teachers with a master's degree presented greater TK knowledge, which tends to favor the development of ICT-mediated teaching and learning activities, compared to teachers with a bachelor's degree. In the rest of the TPACK subdimensions, no significant statistical differences were found.

Table 5- Means, standard deviation and t-test for independent samples according to academic degree

Factors	Bacheleor		Magister		Test t	
Model TPACK	M	SD	M	SD	T(353)	p
TK	3,53	0,78	3,82	0,82	-2,199	0,029
CK	4,09	0,73	4,19	0,49	-0779	0,437
PK	4,26	0,75	4,43	0,37	-1,430	0,153
PCK	4,00	0,80	4,15	0,66	-1,116	0,265
TCK	3,71	0,83	3,92	0,83	-1,527	0,128
TPK	3,88	0,76	4,02	0,76	-1,123	0,262
TPACK	3,86	0,88	3,94	0,82	-0,557	0,578

Relationship between the different variables

Pearson's linear correlation coefficient r was analyzed to study the existence of relationships between the dimensions that make up the TPACK (see Table 6).

The existence of a strong positive correlation was observed between the variables TPK and TPACK (r=0.838), between CK and PK (r=0.744) and between TCK and TPACK (r=0.731).

In addition, the existence of strong positive correlations between TK and the following three variables was observed: TK and TPK (r=0.736), between TK and TPACK (r=0.711) and between TK and TCK (r=0.617).

The increase in TK correlates with the increase in TPACK, TPACK and TCK knowledge. In contrast, the central dimensions that make up TPACK present positive correlations, but weaker, between TK and CK (r 0.369) and between TK and PK (r=0.480).

Table 6- Correlations between the sub dimensions of the TPACK model.

	TK	CK	PK	PCK	TCK	TPK	TPACK
TK	1						
CK	,369**	1					
PK	,480**	,744**	1				
PCK	,372	,715**	,794	1			
TCK	,617**	,568	,551	,522**	1		
TPK	,736**	,484	,604	,493**	,634**	1	
TPACK	,711**	,566**	,607**	,588**	,731**	,838**	1

Note: ** Correlation is significant at the 0.01 level (bilateral)

DISCUSSION

The results show that primary school teachers have greater pedagogical and disciplinary knowledge than technological knowledge, which is consistent with previous studies Paidican (2019), Roig et al. (2015), Roussinos & Jimoyiannis (2019), Schmidt et al. (2009).

Regarding Technological Knowledge (TK), women present better results than men in this knowledge and the interaction with the other dimensions: TK, TCK, TPK and TPACK, which is consistent with the investigations of Beltrán *et al.* (2019), Roig-Vila *et al.* (2015) and Schmidt *et al.* (2009). It should be noted that caution should be maintained regarding the results related to the gender of teachers, since there are investigations where men present better results in Technological Knowledge (TK) than women (Luik*et al.* , 2018; Ortiz-Colon *et al.* , 2020 and Scherer*et al.* ,2017). On the other hand, women present statistically significant differences in Content Knowledge (CK) compared to men.

Regarding the administrative dependency, the teaching staff of subsidized private schools obtain better results in most of the dimensions that make up TPACK, with the exception of Content Knowledge (CK). In addition, statistically significant differences were observed in Pedagogical Content Knowledge (PCK).

Regarding the academic degree, teachers with a master's degree present higher results in all the dimensions that make up the TPACK. It is also observed that teachers with a master's degree obtain statistically significant differences in Content Knowledge (CK). From the results obtained in the correlation analysis, it can be concluded that there are interrelationships between the dimensions that make up the TPACK, with the strongest correlations being between Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Knowledge of Content (TPACK), between Knowledge of the Content (CK) and Pedagogical Knowledge (PK) and between Technological Content Knowledge (TCK) and Technological Pedagogical Content Knowledge (TPACK). In addition, in line with what Roig-Vila *et al.*(2015) , the weakest correlations are found in Technological Knowledge (TK), interrelated with Content Knowledge (CK) and Pedagogical Knowledge (PK).

Regarding the limitations and prospective, it is required in future investigations of probabilistic samples and with the participation of teachers from different regions of Chile, in such a way that the results obtained can be generalized.

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Conflict of interests

The authors declare no conflict of interest.

Authors contribution

All authors managed the information, reviewed the writing of the manuscript and approved the version finally submitted.