Primary Teachers' Technological, Pedagogical and Content Knowledge

Conocimientos tecnológicos, pedagógicos y disciplinares del profesorado de Primaria

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ABSTRACT

The emergence of Information and Communication Technologies (ICTs) poses new educational challenges for teachers, to which it can respond from a consistent training model. This study has as its aim to analyze the technological, pedagogical and content knowledge needed for Primary Education teachers to integrate ICTs into teaching. A research work based on a quantitative non-experimental methodology which involved 224 Preschool and Primary Education teachers working in the province of Alicante (Spain) was performed with that aim. The important results showed that teachers are more knowledgeable in the pedagogical and content fields than in technology, which means that their level of technological knowledge does not suffice to integrate ICTs into their teaching tasks. Significant differences were additionally identified between gender and years of experience, together with the relationship between the fun use of technology and the knowledge of its essential aspects. Our findings confirm the need for a digital literacy campaign addressed to teachers, involving not only a technological type of training but also an overall pedagogical and content approach. This is in keeping with the TPACK model (Technological, Pedagogical and Content Knowledge), which appears as a reference framework to be taken into account when it comes to teachers' professional development and its connection with the teaching-learning processes in the classroom wherever Information and Communication Technologies are present.

RESUMEN

La emergencia de las tecnologías de información y comunicación (TIC) plantea nuevos desafíos educativos al profesorado, a los cuales puede responder desde un modelo de formación coherente. El propósito de este estudio es analizar los conocimientos tecnológicos, pedagógicos y disciplinares del profesorado de Educación Primaria, necesarios para la integración de las TIC en la labor docente. Para ello, se llevó a cabo una investigación con una metodología cuantitativa de carácter no experimental en la que participaron 224 profesores de Educación Infantil y Primaria de la provincia de Alicante. Los resultados mostraron que los docentes poseen mayores conocimientos pedagógicos y disciplinares que tecnológicos, lo que conlleva a escasos conocimientos para la integración de las TIC en la labor docente. Se constataron, además, diferencias significativas entre el género y los años de experiencia docente, y la relación entre el uso lúdico de la tecnología y los conocimientos sobre sus aspectos fundamentales. Según los resultados obtenidos, se corrobora la necesidad de una alfabetización digital del profesorado abordada no solo desde una formación tecnológica, sino también pedagógica y disciplinar de forma global. Ello responde al modelo TPACK (Technological, Pedagogical and Content Knowledge), el cual se contempla como un marco de referencia a tener en cuenta por lo que respecta al desarrollo profesional del profesorado y su vinculación a los procesos de enseñanza-aprendizaje en el aula donde las TIC estén presentes.

1. Introduction

ICTs offer a new and wide range of possibilities for the design and implementation of teaching-learning proposals as an essential part of education that imply the adoption of new teaching methodologies meant to boost students' cognitive development; examples can be found in the proposals made by Sánchez, Prendes and Fernández (2013) and Marín, Negre and Pérez (2014). Nevertheless, the mere introduction of technological media does not guarantee success in the teaching-learning process, since a suitable didactic design is required too. The responsibility for providing the different resources therefore falls upon teachers, who have to refine their training accordingly. A large number of researchers agree both on the central role that ICT training has for teachers and on the need for the latter to achieve digital literacy (Paechter, 2010).

The traditional model based on the simple transmission of information from the teacher to the student has started to prove ineffective for learning development: «a change in the teacher's role» is required (Cabero, 2003; De Benito & al., 2013). Furthermore, «information and communication technologies reach up to the last corner of everyday life» (Aguaded-Gómez & Pérez-Rodríguez, 2012), what suffices to justify the use of ICTs in the classroom that, in our opinion, cannot ignore what exists in society.

Before this situation, the new educational paradigm needs to incorporate both new skills and capabilities (Herrera & Bravo, 2012) and new resources, technological ones in this case, which can make it easier for students to acquire basic competences. Teachers' digital literacy campaigns thus seem essential to us when it comes to mastery in the use of technological instruments and their educational integration. The TPACK (Technological Pedagogical Content Knowledge) model developed by Mischra and Koehler (2006) identifies the specific knowledge that teachers need to own for that integration to exist. According to this model, an adequate utilisation of technology in teaching requires a type of teacher training based on different sorts of knowledge, which can be summarised in the idea of being able to use an effective methodology for the implementation of ICTs supporting pedagogical strategies and methods in relation to a specific discipline. The present proposal about ICT integration into the educational context thus means a systematisation and re-definition of the role played by the teaching staff as active agents in educational progress. It also implies –as explained in more detail in one of our previous works (Roig & Flores, 2014)– a model where teachers' knowledge is re-defined and interacts

in an original way for the purpose of dealing with the teacher training required within the new learning scenarios arising from ICT presence.

The TPACK model therefore represents the knowledge needed by teachers bringing together content knowledge, technological knowledge and pedagogical knowledge with the aim of integrating ICTs into teaching-learning processes (Graham, 2011). Thus, a variety of other knowledge types result from the intersection of these three general types (Mishra & Koehler, 2006):

• Technological Knowledge (TK): it refers to the knowledge about all sorts of technology –not only computers.

• Content Knowledge (CK): it covers the knowledge linked to a subject matter.

• Pedagogical Knowledge, PK: it corresponds to teaching methods and processes, and includes: knowledge about classroom management and organisation; curricular analysis and planning; and student's learning.

• Pedagogical Content Knowledge (PCK), referred to the content knowledge associated with the teaching-learning process, integrating content and pedagogy with the aim of developing better teaching practices.

• Technological Content Knowledge (TCK), associated with the knowledge of the way in which technology can create new learning scenarios for specific contents.

• Technological Pedagogical Knowledge (TPK): it entails understanding how several technological tools can be used in teaching, along with the conviction that the use of technology can change the way in which teachers develop their professional activity.

• Technological Pedagogical Content Knowledge (TPACK): this is the knowledge required for teachers to integrate technology into the teaching of any content area. Teachers have an intuitive knowledge of the complex interrelationships existing between the three basic component of knowledge (CK, PK, TK) which is reflected in their ability to teach using the appropriate pedagogical methods and technologies.

An optimal integration of technology consequently requires understanding and approaching the three types of knowledge (Technological Pedagogical Content Knowledge) collected in the core of this model. Numerous experiences have been developed under these premises, both in the context of initial teacher training (Jang & Chen, 2010; Pamuk, 2012; Srisawasdi, 2012; Maeng, Mulvey, Smetana & Bell, 2013; Mouza, Karchmer-Klein, Nandakumar & Oz-
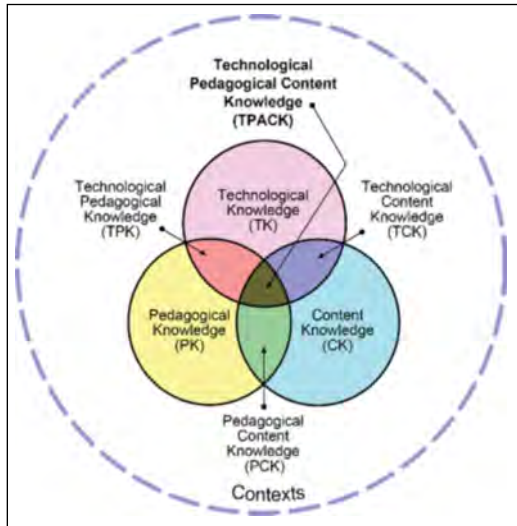
Figure 1. TPACK Model (www.tpack.org).

den, 2014) and in different content fields and educational levels (Erdogan & Sahin, 2010; Graham, Borup & Smith, 2011; Jang & Tsai, 2012; Lescano, 2013; Lye, 2013; Nordin, Davis & Tengku, 2013). In the present case, it is our belief that the TPACK model can be applied in Primary Education, which requires the a priori establishment of the perceptions that teachers who develop their professional activity in these educational stages own in connection with the knowledge made explicit in the TPACK model. Such perceptions will serve as a guide to define the integration of ICTs into the classroom (Kim & al., 2013; Lin, Tsai, Chai & Lee, 2013; Koh & Chai, 2014).

2. Materials and methods

Based on the TPACK model, the present research sets itself the goal of knowing and analysing technological, pedagogical and content knowledge with regard to teachers' ICT integration into their teaching tasks, in this specific case, in the Preschool and Primary Education Centres located in the province of Alicante (Spain). It is likewise our intention to inquire about whether a link exists between the results obtained and the variables 'gender' and 'years of experience' – referred to participants.

Concerning the method utilised, the choice made was a descriptive, comparative and correlational non-experimental quantitative, questionnaire-based design (McMillan & Shumacher, 2005). In our view, this was the most suitable method taking into account that the research was developed within a real context (Lozada & López, 2003) – as it allowed us to analyse, to get to know, to describe, and to discover reality.

The sample was selected in an incidental, convenience-based way (McMillan & Shumacher, 2005), and it included 224 teachers who imparted classes in 12 public Preschool and Primary Education centres of the Alicante province during the 2013/2014 year. 183 of them (81.7%) were females, and 41 (18.3%) males, the age range being between 21 and 60.

As for the information collecting instrument, a translated and simplified version of the original questionnaire elaborated by Schmidt, Baran, Thompson, Mishra, Koehler and Shin (2009) was used to analyse teachers' knowledge according to the TPACK model. It deserves to be highlighted that this questionnaire has a «dynamic» nature, insofar as subsequent studies have focused on it (Yeh, Hsu, Wu, Hwang and Lin, 2014; Yurdakul & al., 2012; Saengbanchong, Wiratchai & Bowarnkitiwong, 2014) and it has been used in various research works, too (Nordin, Davis & Tengku, 2013; Kopcha, Ottenbreit-Lefwich, Jung & Baser, 2014). It has Cronbach's α reliability studies between 0.82 and 0.92 for its different subscales, and the content validity ratio proposed by Lawshe (1975) served to examine instrument content validity (IVC); the instrument was subjected to the criterion of 12 expert judges, university lecturers from the Educational Technology field. The overall IVC coefficient revealed a high ratio (.73) –highly suitable for the number of expert evaluators involved.

The questionnaire utilised covers with not only the same dimensions as the original questionnaire but also with the same demographic data (working centre; gender; age; and years of experience). It consists of 29 items on a 5-point Likert scale –I totally disagree (TD); I disagree (D); I neither agree nor disagree (N); I agree (A); and I totally agree (TA)– which relate to the diverse intersections which –as seen above– shape the TPACK model: TK: items 1, 2, 3, 4, 5, 6 and 7; CK: items 8, 9 and 10; PK: items 11, 12, 13, 14, 15, 16 and 17; PCK: item 18; TCK: item 19; TPK: items 20, 21, 22, 23 and 24; and TPACK: items 25, 26, 27, 28 and 29.

In relation to design, it is worth highlighting that a basic correlation method or ex post facto study was used in this research. More precisely, this is a transversal study with a single-group ex post facto design or predictive-type correlational design (Creswell, 2012) in which a large group of subjects is selected and one or several independent variables (gender, years of experience, etc.) related to the dependent variable (manipulation by selection of values) are measured, groups are formed, and the dependent variable (TPACK) is subsequently measured.

As for the procedure, questionnaires were distributed both in paper and in electronic format –using Google Drive– throughout the 2013/2014 academic year. A descriptive data examination was firstly performed with regard to statistical analysis. The comparison of means t-test for independent samples served to assess the influence exerted by teachers' gender on TPACK knowledge, and the comparison of results according to years of experience (since more than two groups are to be compared) was possible through a covariance univariate analysis (or single-factor ANOVA); finally, Pearson's linear correlation r coefficient helped establish the relationship between the different variables.

The Statistical Package for Social Sciences (SPSS) version 21 for MacOS was used for data structuring, organisation and analysis.

3. Results
3.1. Descriptive analysis: TPACK model
The development of our study started from the structure of the TPACK questionnaire according to the seven factors specified in the Instruments subsection. Figure 2 shows the results corresponding to the descriptive statistics obtained for each item on all seven subscales.

On the whole, teachers are more knowledgeable in non-technology-related TPACK model areas. The factors with better behaviours would be content knowledge CK (M=4.22; SD=0.694), pedagogical knowledge PK (M=4.27; SD=0.61) and their intersection: pedagogical content knowledge PCK (M= 4.19; SD=0.70). Teachers consider that they have enough knowledge about the subject that they impart (M=4.22; SD=0.80) and know how to apply that knowledge (M=4.26; SD=0.74). They also see themselves as being able not only to assess the performance of a particular student in class (M=4.38; SD= 0.71), adapting their teaching to multiple learning styles (M= 4.18; SD=0.76) and assessing students' learning in different subjects (M=4.33; SD=0.69), but also to organise and maintain an orderly development of the class (M=4.34; SD=0.67). In short, and adding up both skills, teachers believe that they can choose effective didactic approaches meant to guide students' reasoning and learning (M=4.19; SD= 0.67).

The factor where teachers obtain the worst result is that of technological knowledge TK (M=3.16;

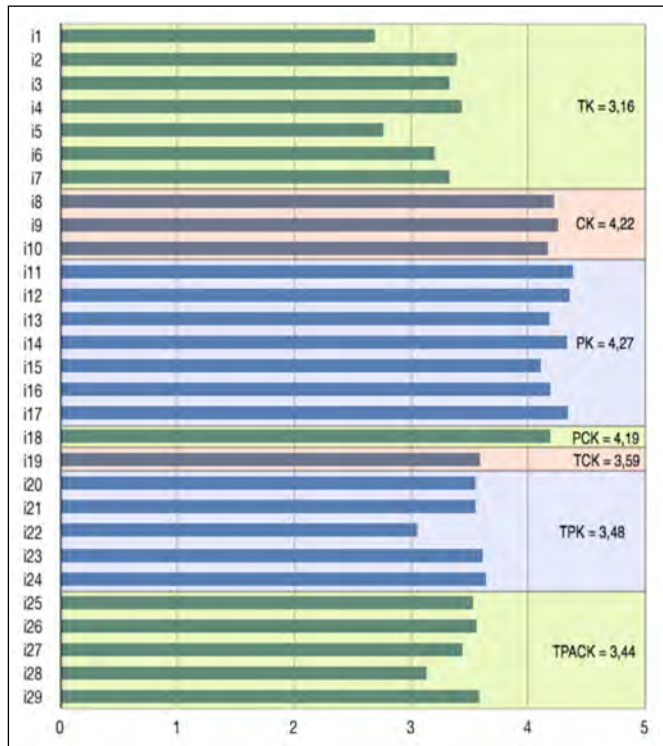Figure 2. Descriptive analysis of the TPACK questionnaire.

SD=0.89), closely followed by the intersections of the three basic types of knowledge (TK, CK, PK) where technology plays a role, namely: technological content knowledge TCK (M=3.59; SD=0.95); technological pedagogical knowledge TPK (M=3.48; SD=0.83) and technology, pedagogical and content knowledge TPACK (M=3.45; SD=0.96). Teachers do not think they will be able to solve technical problems (M= 2.69; SD=1.20); and neither do they think that they own much knowledge about different technology elements (M=2.76; SD=1.11). Views additionally differ when it comes to keeping up to date with important new technologies (M=3.33; SD=1.10), both in terms of using technology for fun purposes (M=3.43; SD= 1.21) and regarding the availability of sufficient opportunities to work with different technology elements (M=3.33; SD=1.08). In turn, there are also a multiplicity of views about the knowledge of technological elements which they can use to improve understanding (M=3.59; SD=0.95), in the choice of technological elements meant to improve the learning of a didactic unit (M=3.55; SD=1.02), and in the adaptation of technological elements recently learnt by the teacher to various didactic activities in the classroom (M=3.64; SD=0.99).

As for the issues directly related to TPACK know-

ledge, teachers are not too sure about how to elaborate a Didactic Unit where contents, technological elements and the didactic approach can combine (M= 3.53; SD=1.03); and neither do they clearly know how to choose the technology that will subsequently be used to complement what is taught (M=3.56; SD= 1.00) or how to utilise classroom strategies that combine contents, technology, and didactical approaches (M=3.13; SD=1.20).

3.2. Comparative analysis according to gender and years of teaching experience

After carrying out the descriptive analysis, a comparison was drawn between the means of the different TPACK model components for the purpose of checking if significant differences existed according to the independent variables (gender and years of experience). With that aim, t-tests for independent samples were performed when only two groups were compared (according to gender), and a univariate analysis of variance (ANOVA) in cases where the comparison was made between more than two groups, according to years of teaching experience. Pearson's linear correlation r coefficient served to analyse the relationship between the different variables.

3.2.1. Comparison of means according to gender

A t-test for independent samples was carried out in order to compare TPACK model components among men and women; its results can be seen in table 1.

Significant differences appeared in all the knowledge sectors associated with technology, such as technological knowledge TK for men (M=3.56; SD= 0.75) and women (M=3.07; SD=0.90); t(222)= 3.023, p=0.002. The same significant differences were found in technological content knowledge TCK in males (M=3.90; SD=0.86) and females (M=3.52; SD=0.96); t(222)=2,320, p=0.021, as well as in technological, pedagogical and content knowledge TPACK among males (M=3.72; SD=0.84) and females (M=3.38; SD= 0.98); t(222)= 2.043, p= 0.042.

The aforesaid results suggest that men are more familiarised with technical knowledge and its didactic application than women or, alternatively, that women reject technologies to a greater extent. No significant differences appeared in the

rest of factors. The fun use of technology according to gender was additionally examined, with no significant differences being found between males (M=3.44; SD= 1.28) and females (M=3.43; SD=1.20); t(222)= 0.061, p=0.951).

3.2.2. Comparison of means according to years of teaching experience

An ANOVA single-factor variance analysis subsequently helped us to compare the effect caused by years of teaching experience on the knowledge for ICT integration following the TPACK model. As for participants' years of experience, the 224 sample members were classified into four subgroups formed by 57 individuals (25.4 % of the sample) whose experience ranged between 0 and 7 years; 79 people (35.3 %) with 8-to-15 years' experience; 37 participants (16.5 %) who had between 16 and 23 years' experience; and the remaining 51 (22.8 %), whose experience exceeded 23 years.

According to the results expressed in Table 2, it was found that years of experience cause a significant effect on TPACK model knowledge at a p<0.05 level for technology-related factors such as technological knowledge TK [F(5.224)=2.865, p=0,016], personal involvement PI [F(3.220)=11.946, p=0,000], technological content knowledge TCK [F(3.220)= 8.454, p=0.000], technological pedagogical knowledge TPK [F(3.220)=5.503, p=0.004], and technological pedagogical content knowledge TPACK [F(3.220)= 8.936, p=0.000].

Post-hoc comparisons using HDS Tukey's test indicate that the means among teachers with 0-to-7 years' experience significantly differed from those with over 23 years' experience for all these components. More specifically, in the case of the TK factor, the means of teachers with 0-7 years' experience (M= 3.46; SD=0.80) were significantly different from those of teachers who accumulate an experience ranging between 16 and 23 years (M=3.00; SD=0.95) as well as from those with over 23 years' experience

Table 1. Means, standard deviations and t-test for independent samples according to gender						
Factors	Males		Females		T-test	
TPACK Model	M	SD	M	SD	$t_{(222)}$	p
TK	3,56	0,75	3,07	0,90	3,203	0,002
CK	4,28	0,55	4,20	0,72	0,618	0,537
K	4,20	0,54	4,29	0,62	-0,832	0,406
PCK	4,15	0,61	4,20	0,71	-0,418	0,676
TCK	3,90	0,86	3,52	0,96	2,320	0,021
TPK	3,72	0,78	3,43	0,88	1,946	0,053
TPACK	3,72	0,84	3,38	0,98	2,043	0,042
* All the equal variances according to Levene's Test have been assumed (p >0.05).						

(M= 2.61; SD= 0.91). The same occurs for the TCK factor between the groups of 0-7 years (M= 3.86; SD= 0.86) and >23 years (M=3.08; SD= 1.07), for the TPK factor between the groups of 0-7

Table 2. Means and single factor ANOVA analysis according to years of teaching experience						
Factors	YEARS OF TEACHING EXPERIENCE				ANOVA	
TPACK Model	0-7 years	8-15 years	16-23 years	>23 years	F	p
TK	3,46	3,37	3,00	2,61	11,946	0,000
CK	4,07	4,39	4,25	4,08	3,342	0,160
PK	4,10	4,32	4,34	4,32	2,096	0,102
PCK	4,01	4,20	4,22	4,33	1,935	0,125
TCK	3,86	3,78	3,49	3,08	8,454	0,000
TPK	3,59	3,65	3,46	3,12	4,503	0,004
TPACK	3,55	3,76	3,33	2,93	8,936	0,000
* The mean homogeneity variance test according to Levene's statistic results in equal variances for every case (p >0.05).						

years (M=3.59; SD=0.74) and >23 years (M=3.12; SD=1.00), and in TPACK, with significant differences becoming visible between 0-7 years (M=3.55; SD= 0.82) and >23 years (M=2.93; SD= 1.12). However, no significant differences appear between the remaining intermediate educational levels. On the whole, it can be said that significant differences arise for the TK, TCK, TPK and TPACK factors between few and many years of experience when it comes to technological knowledge and its didactic application.

3.2.3. Relationship between the different variables

Pearson's linear correlation r coefficient was analysed in order to study the relationship existing between the different TPACK model components, and between the latter and teaching experience with the fun use of technology. The correlational results can be found in Table 3 below.

A careful observation of table 3 allows us to appreciate the links existing between the different TPACK model components. The components more closely related to one another are the intersections directly linked to technology, such as TCK, TPK and TPACK. A strong positive correlation exists between the variables TCK and TPK (r=0.840, n=224, p= 0.000), between TCK and TPACK (r=0.821, n= 224, p=0.000) and between TPK and TPACK (r=0.879, n=224, p=0.000). Similarly, there is a

fairly strong positive correlation between TK and these three variables (between TK and TCK r=0.761, n=224, p=0.000; between TK and TPK r=0.701, n=224, p=0.000, and between TK and TPACK r=0.745, n=224, p=0.000). An increase of technological knowledge was correlated with the increased understanding of: technological content knowledge; technological pedagogical knowledge; and technological, pedagogical and content knowledge. Nevertheless, technical, pedagogical and content knowledge TPACK presents a positive –though weak– correlation with TPACK (between CK and TPACK r=0.271, n=224, p=0.000; between PK and TPACK r= 0.238, n=224, p=0.000; between PCK and TPACK r=0.257, n=224, p=0.000).

With regard to years of teaching experience, this factor correlates negatively –though not excessively– with factors linked to technology. By way of example, years of teaching experience correlate negatively with technological knowledge r=-0.362, n=224, p= 0.000; with TCK r=-0.308, n=224, p=0.000; and global knowledge TPACK r=-0.274, n=224, p= 0.000). Nevertheless, no correlation exists between years of experience and content knowledge or pedagogical knowledge.

The link between the fun use of technology and the model components was analysed as well. A fairly strong positive correlation appeared between the fun use of technology and technological knowledge TK, r= 0.696, n= 224, p=0.000; and also positive with TCK r=0.525, n=224, p=0.000; with TPK r=0.491, n= 224, p=0.000; and with TPACK=

Table 3. Correlations between variables according to Pearson's linear correlation r coefficient									
	TK	CK	PK	PCK	TCK	TPK	TPACK	exp	i4
TK	1								
CK	0,281**	1							
PK	0,112	0,635**	1						
PCK	0,174**	0,500**	0,727**	1					
TCK	0,761**	0,228**	0,171*	0,244**	1				
TPK	0,701**	0,255**	0,250**	0,310**	0,840**	1			
TPACK	0,745**	0,271**	0,238**	0,257**	0,821**	0,879**	1		
exp	-0,362**	-0,026	0,123	0,151*	-0,308**	-0,209**	-0,274**	1	
i4	0,696**	0,243**	0,142*	0,245**	0,525**	0,491**	0,500**	-0,318**	1
** p<0,01; * p<0,05; exp=years of teaching experience; i4=fun use of technology									

0.500, n=224; p=0.000. Furthermore, the fun use of technology presented a negative correlation with years of teaching experience r=-0.318, n=224, p=0.000.

4. Discussion and conclusions

As highlighted by Cabero (2003), a change in education is not possible without a change both in the teaching staff's mind-set and in curricular approaches. Technology consequently needs to be integrated into the educational context according to curricular and pedagogical needs, and not the other way round (Mishra & Koehler, 2006). For this reason, teachers must design such context on the basis of the three types of acquired knowledge –technological, pedagogical and content– that shape the TPACK model. Therefore, it will become essential to know what knowledge items are seen as acquired by teachers with the main aim of suggesting the guidelines for their training and professional development.

Results show that teachers in the Primary Education stage have more content and pedagogical knowledge than technological knowledge, as proved by the average scores obtained in each questionnaire factor. This confirms the premises posed by other researchers such as Schmidt and al. (2009) or Koh and Chai (2014) and, partially, the one developed by Nordin, Davis and Tengku (2013), insofar as results corresponding to technological knowledge were lower in the latter case.

As for technological knowledge, it deserves to be mentioned that women obtain worse results than men in this type of knowledge and its intersections with the others, since significant differences are visible in the TK, TCK and TPACK factors. Similarly, the study carried out by Erdogan and Sahin (2010) showed males achieving a higher score, not only in these dimensions but in all of them as a whole.

Moreover, the comparison of TPACK model results with years of teaching experience (which generally means older teachers) reveals the progressive reduction of technological knowledge in teachers with a greater teaching experience, significant differences appearing in every technological factor (TK, TCK, TPK and TPACK) between teachers with few and many years of teaching experience, as suggested by Koh and Chai (2014).

The results obtained according to the correlational analysis corroborate the interrelationship between the variables in the model that were graphically presupposed according to Figure 1. In tune with Erdogan and Sahin (2010), it can be concluded from the analysis of correlations between the different variables and the

descriptive results that when low results are obtained in technological knowledge, low results are also obtained in its intersections with the other basic types of knowledge (pedagogical and content knowledge), which in turn entails low results in technological, pedagogical and content knowledge –needed for a good integration of ICTs into teaching tasks following the TPACK model.

The same as in the study carried out by Graham, Borup and Smith (2012), though referred exclusively to teachers in the initial training stage, a positive relationship can be inferred from the correlational analysis performed between: fun use of technology; technological knowledge; technological content knowledge; technological pedagogical knowledge; and technological, pedagogical and content knowledge. Therefore – in keeping with Kim and al. (2013) – the same as the utilisation of technological tools regularly used by students outside school in teaching boosts those students' motivation and interest, a fun use of technology on the part of teachers will surely reduce the degree of reluctance towards them and favour their use in the teaching process.

Concerning limitations and prospects, it is worth highlighting that even being optimistic with the study findings as far as ICT integration into teaching is concerned, one must be aware of the fact that these conclusions are provisional. This provisional nature of results has to do with the size of the sample –since no sample size calculation estimate could be made with a sample which was not probabilistic but convenience-based– and with the fact that the study scope cannot be generalised to the whole teaching profession –our work focuses on a single Spanish geographical area: the Alicante province. It is likewise necessary to be cautious with the results linked to gender differences, insofar as the sample was quite imbalanced with respect to this variable.

It would be interesting for future research initiatives to extend the study follow-up period so that participants can be assessed after some time has elapsed or once an ICT training process for teachers has started. This will help to check if variations exist in their answers and, consequently, to verify the potential appearance of increased knowledge according to the TPACK model with the passing of years. Another interesting possibility would consist in investigating the link between teachers' beliefs and practices because, as suggested by Graham, Borup and Smith (2012), that can prove of paramount importance when it comes to understanding the effective integration of technology.

In short, it is necessary to ensure the teaching

staff's digital literacy and, of course, to introduce modifications in their mind-set so that a change can be achieved in education as well as in teaching techniques – better suited to the new educational challenges generated by the presence of ICTs in today's society. The ultimate objective sought with our study was to provide a justification for the proposal of the TPACK model as a valid reference framework for the analysis of the teacher training-effective ICT integration tandem.

Support

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