Computers & Education 100 (2016) 110–125

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Teachers' information and communication technology competences: A structural approach

Gonzalo Almerich, Natividad Orellana, Jesús Suárez-Rodríguez*, Isabel Díaz-García

Faculty of Philosophy and Sciences Education, University of Valencia, Spain

A R T I C L E I N F O

Article history:
Received 12 February 2016
Received in revised form 2 May 2016
Accepted 6 May 2016
Available online 10 May 2016

Keywords:
ICT competences
Teacher
Primary education
Secondary education
Higher education

A B S T R A C T

Teachers' information and communication technology (ICT) competences are a key variable to integrate such resources into the teaching-learning process. One problem with teachers' ICT competences is the proliferation of various frameworks which entail a lack of definition of these competences. The objective of this article is twofold: to establish a basic framework that shapes the subsets of ICT competences (technological and pedagogical) in all teachers at all levels (Primary, Secondary and Higher Education); to determine how various personal and contextual factors influence these subsets. For this purpose, a study of secondary analysis has been made with data from two survey design studies on teachers' ICT competences that collect information from a sample of 1095 male and female Primary, Secondary and Higher Education teachers in the Valencian Community (east Spain). A Multiple Indicators and Multiple Causes Model (MIMIC) was used to validate the teachers' ICT competences model. The study results indicated that teachers' ICT competences form a unique set composed of two subsets, technological competences and pedagogical competences. Moreover, the technological competences influenced the pedagogical ones. We also found that personal and contextual factors have a relevant impact on the competences subsets. This article helped clarify and delimit the framework of teachers' ICT competences. Besides, this basic model of ICT competences should be a key element for teacher training in ICT. This article also shows how the influence of personal and contextual factors must be considered when designing training plans.

1. Introduction

Information and communication technologies (ICT) have profoundly changed our society and are the basis of today's knowledge society. Education has not remained indifferent to this change, at least not as far as two aspects are concerned: the impact of citizens training and the education system itself. The former refers to the challenge faced by the education system to train citizens for a society in which ICT form part of their lives. The latter corresponds to how ICT are integrated into the education system and their use in teaching-learning processes.

Such a profound transformation in education, and consequently in the education system itself, has been accelerated by various education administrations from different countries. Nevertheless, the introduction of ICT into the education system

* Corresponding author. Department of Research Methods and Educational Diagnosis, Faculty of Philosophy and Sciences Education, University of Valencia, Av. Blasco Ibáñez 30, 46010, Valencia, Spain.
E-mail address: Jesus.M.Rodriguez@uv.es (J. Suárez-Rodríguez).

http://dx.doi.org/10.1016/j.compedu.2016.05.002
0360-1315/

over the last two decades has not involved development and impact that was expected of them, despite its potential (Ertmer & Ottenbreit-Leftwich, 2010; Hixon & Buckenmeyer, 2009; Kirkup & Kirkwood, 2005; Ramboll Management, 2006; Sandholtz & Reilly, 2004; Whitworth, 2012), requiring empirical evidence which provides the benefits of these investments in use of ICT in schools and the education system (Bilbao-Osorio & Pedró, 2009). To a certain extent, the paradox of Cuban, Kirkpatrick, and Peck (2001) has been fulfilled, that of good ICT access, but poor ICT use. This has led to some countries promoting plans to integrate these educational resources (Eurydice, 2011; Office of Educational Technology, 2010). Apart from improving infrastructures, teachers and teacher training become a fundamental point for ICT integration, just as Angeli and Valanides suggested (2009).

Consequently, teachers are the key element to introduce ICT into educational practice. Without these essential agents, integration of technological resources would never take place, as this responsibility is assumed essentially by teachers (Ertmer, 2005; Pelgrum & Law, 2003; Stensaker, Maassen, Borgan, Oftebro, & Karseth, 2007; UNESCO, 2011; Voogt, Knezek, Cox, Knezek, & ten Brummelhuis, 2013). Clearly, these agents need to master them to be able to implement them in their teaching practice. This implies that teachers acquire the technological and pedagogical knowledge and skills needed in order to integrate ICT into their teaching practice. In other words, teachers have to be technologically and pedagogically competent in such resources because if not, they will be unable to include them in their day-to-day educational practice (Buabeng-Andoh, 2012; Guzman & Nussbaum, 2009; Kabakci Yurdakul & Coklar, 2014; Markauskaite, 2007; Okojie, Olinzock, & Okojie-Boulder, 2006; Wastiau et al., 2013).

The need for competent teachers in ICT has meant that several models of competence in ICT – digital competence, digital literacy (Hall, Atkins, & Fraser, 2014; Krumsvik, 2011, 2014; Tondeur et al., in press; Wastiau et al., 2013) – have been proposed in recent years for teachers. These different proposals (explained later) have entailed certain lack of definition of the same construct, as Hall et al. (2014) also pointed out. This is due to the differences among them; e.g. those developed by the International Society for Technology in Education [ISTE] (2008), UNESCO (2011), or Technological Pedagogical Content Knowledge (TPACK). Overall these models are defined according to a general basis, which means that they can be applied to all teachers in the education system, from Primary Education to Higher Education, just as UNESCO indicates (2011). Nevertheless, one of the main questions to arise from these models is if the ICT competences of all the teachers in the Education System actually maintain certain common and basic aspects or, if diversity exists, if completely different competence models are required in various parts of the Education System. This led this article to pose the following questions:

- Does a basic ICT competences model exist for teachers?
- Is the basic model common for all teachers at all levels of education?
- Do personal and contextual factors influence the ICT competences model?

This article deals with these questions as it tackles the definition of a basic ICT competences model for teachers, and also at verifying if this proposed model takes the same structure for all teachers from Primary Education to Higher Education. It is a matter of providing a theoretical and conceptual framework for the ICT competence map to help teachers understand the integration of such resources into classes. In this way, the various suggestions made to obtain a simpler and more contextualised definition of teachers' ICT competences (Ottestad, Kelentrić, & Guðmundsdóttir, 2014), empirically validate a framework of ICT competence (Tondeur et al., in press), mitigate lack of knowledge on integrating educational technology (Angeli & Valanides, 2009) and the need to build a new robust theoretical framework for this purpose (Chai, Ng, Li, Hong, & Koh, 2013) are covered. More specifically, it is a matter of integrating suggestions from various approaches, such as limitations in research works by teachers being trained (Chai, 2010), teachers' knowledge of ICT integration (Hsu, 2010), call to action to develop and employ teacher training models in ICT in class (Voogt, Knezek, et al., 2013; Voogt, Fisser, et al., 2013; Voogt, Erstad, et al., 2013), verifying a unit model (UNESCO, 2011), or the need to develop complex models with interrelated factors (Karaca, Can, & Yildirim, 2013).

Moreover, competences are an essential component if compared with other variables; for instance, the relation between use and competences (Chai, 2010; Law & Chow, 2008; Sipilä, 2014), with ICT integration in classroom (Hew & Brush, 2007; Inan & Lowther, 2010; Vanderlinde, Aesaert, & van Braak, 2014), attitudes (Knezek & Christensen, 2008; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012) and students' use of ICT for learning during lessons (Wastiau et al., 2013).

This work proposes an ICT competences model for all teachers in the Education System (Primary Education, Secondary Education and Higher Education) in order to know if the stable structure of ICT competences remains. Besides, knowledge of teachers' level of ICT competences is essential to be able to present realistic proposals that adapt to teachers' specific requirements. Such knowledge will allow the development of more general teacher training plans for ICT as the proposed ICT competences models can be taken as references. Moreover, having a common model for all levels of education –non-university and university-will facilitate the evaluation of the progress, training efficacy and investment made in integrating ICT into education.

1.1. The framework of teachers' ICT competences and characteristics

As mentioned earlier, teachers are the main agents to integrate ICT into the teaching-learning process. ICT competences are a key factor to enable teachers to change their educational practice and to implement these technologies in their educational practice (Ertmer & Ottenbreit-Leftwich, 2010), and explain. This allows teachers to feel that they can trust the use of such technological resources; that is, they feel completely competent to introduce them into their educational practice.

An essential aspect to achieve such integration is to know which ICT competences teachers must acquire. From a general viewpoint, ICT competences can be considered the teachers' skill to use them (Aesaert & van Braak, 2015). The use of these technological resources by teachers implies much more than merely technically mastering them, but the pedagogical use of ICT (Krumsvik, 2014). It is also necessary to consider that teachers use them in their educational practice. Therefore, competences explain the degree that teachers use ICT (Bilbao-Osorio & Pedró, 2009).

So from our point of view, ICT competences can be understood as a series of knowledge and skills that teachers must acquire in various technological resources so they can introduce them completely into their teaching practice. Despite this being a central theme to implement this integration process, the scientific literature offers very few empirical studies into teachers' ICT competences (Hall et al., 2014; Tondeur et al., in press) and which determine how to arrange ICT competences. Guzman and Nussbaum (2009) pointed out the need to build competence models that support the incorporation of technology into training processes.

Accordingly, this section reviews ICT competence models for teachers, which have been grouped into three sets according to the characteristics that various approaches present.

The first set is made up of organisations that have proposed competence models. A first model is European project DIGCOMP, drawn up by the Institute for Prospective Technological Studies. The scope of this proposal is wide (Ferrari, 2013) as it was conceived to be applied to all levels of education and with all citizens. So it can be adapted to teachers; e.g., the Spanish education system in which the teacher's ICT competences framework has been based in these scheme. Particularly with teachers in mind, proposals have been expressly developed for them, e.g. the ISTE (2002, 2008), UNESCO (2002, 2008, 2011) and EPICT models (2008). Based on these teacher proposals, two of the main characteristics that they all present are related to their arrangement. The first is that several institutions, for example ISTE (2008) and UNESCO (2011), have arranged competences into various levels or stages which teachers must reach so that each corresponds to certain technological and pedagogical competences. There are three levels: basic, intermediate and advanced. The second characteristic of the proposals is that they address different teacher groups; some are dedicated to teacher training in the classroom, and others to coordinators' training in educational technology, principals or coaches. However, these proposals have one limitation; lack of explicit agreement about defining a common competence framework. This cannot be avoided as each model has its own dimensions.

A second set comprises technological pedagogical and content knowledge (TPACK). Until quite recently, the term TPACK has been introduced as an extension of knowledge of the pedagogical content according to Shulman (1986, 1987), to which the technological component has been added. Although other models related to TPACK have been developed over the years (Ay, Karadağ, & Acat, 2015; Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013), according to Angeli and Valanides (2013) two principal perspectives in TPACK are indicated: the integrative model and the transformative model. The integrative model is represented by Koehler and Mishra (2005); Mishra and Koehler (2006). This term includes three classes of knowledge and their interrelations: Content, Pedagogy and Technology. With these, Koehler and Mishra (2005); formulated seven types of knowledge: pedagogical knowledge; content knowledge; technological knowledge; pedagogical content knowledge; technological pedagogical knowledge; technological content knowledge; technological pedagogical content knowledge. Angeli and Valanides (2005, 2009) represent the second perspective, the transformative model, and proposed a unique technological pedagogical content knowledge model for ICT (ITC-TPCK) based on five knowledge types: ICT; pedagogical; content; students; context. Yet as Graham (2011) pointed out, the constructs that correspond to TPACK present problems at the theoretical level, and require a more accurate definition of each one and its interrelation. In practice, Kopcha, Ottenbreit-Leftwich, Jung, and Baser (2014) founded in their study, the practical implementation of the TPACK, that the model presents problems as to the clarity of various constructs. Thus the theoretical TPACK outline is still problematic and requires a profounder definition (Voogt, Knezek, et al., 2013; Voogt, Fisser, et al., 2013; Voogt, Erstad, et al., 2013). So despite Chai et al. (2013) validating the 7-factor TPACK outline, the technological content knowledge and technological pedagogic knowledge showed a strongly significant relation to technological pedagogical content knowledge, and not such a direct or intense one with the other constructs. In another study with pre-service and in-service teachers, Dong, Chai, Sang, Koh, and Tsai (2015) found similar relations to the previous study between technological content knowledge and technological pedagogic knowledge in relation to technological pedagogical content knowledge, and in such a way that the first two were strong predictors of TPACK. Likewise, Chai et al. (2013) indicated that the items which refer to technologies tend to group around one factor, while those that relate to pedagogic content tend to group around another factor. From the research done on TPACK construct validation, e.g., Shinas, Yilmaz-Ozden, Mouza, Karchmer-Klein, and Glutting (2013), Jang and Tsai (2012) and Koh, Chai, and Tsai (2010) indicate lack of clarity of TPACK constructs. Shinas et al. (2013) found an 8-factor structure, with an outstanding link among the items of technological pedagogical knowledge, technological content knowledge and technological pedagogical content knowledge. From the studies by Jang and Tsai (2012) and Koh et al. (2010), it can be concluded that apart from content knowledge and pedagogic content knowledge, there are two types of knowledge: technological knowledge and technological pedagogical content knowledge (Jang & Tsai, 2012) or technology teaching knowledge (Koh et al., 2010). So a close relation seems to link technological pedagogical knowledge, technological content knowledge and technological pedagogical content knowledge which, according to Chai (2010), implies pedagogical knowledge in ICT competences.

Finally, the third set comprises a series of authors who have put forward various proposals on ICT competences for teachers. The first proposal was that by Baylor and Ritchie (2002), who differentiated between technology integration and technological competence as far as teachers' skills are concerned. The second proposal was put forward by Markauskaite (2007), who distinguished between two types of general ICT-related capacities: cognitive and technological. Cognitive capacities are grouped as two factors: problem solving; communication and metacognition. ICT-related technical capacities are grouped as three factors: basic ICT capacities; analysis and production with ICT; Information and the Internet. The third was proposed by Guzman and Nussbaum (2009), whose literature review concluded that there are six teaching domains and competences needed to support teacher training processes: instrumental/technological; pedagogical/curricular; didactic/methodological; evaluative/investigative; communicational/relational; personal/attitudinal. The fourth proposal was that by Hsu (2010), who stated that the evaluation of teachers' ICT integration has obtained a low degree of consensus. This author indicated that teachers' technology integration entails a multifaceted knowledge series based on three types of use: technology, pedagogy and the curricular context. These domains and competencies are the basis for modelling technology integration training. Hsu (2010) also stated that there are six subscales in teachers' ICT integration; three linked to use of technology: preparation (information collection and preparation), production (material producing and troubleshooting) and communication (communication and sharing). The other three focus on pedagogical consideration and professional development: instruction (planning, teaching and evaluation), development (professional development and self-study) and ethical, health and safety issues. A fifth proposal is that by Hall et al. (2014), who established a framework for Secondary Education that had four levels −entry, core, developer and pioneer- and six key areas that related more to the teaching practice: Finding, Evaluating and Organising; Creating and Sharing; Assessment and Feedback; Communication, Collaboration and Participation; E-Safety and Online Identity; and Technology supported Professional Development. The sixth proposal is that by Ottestad et al. (2014), who established three teacher digital competences dimensions: generic digital competences (similar to general digital competences descriptions), didactic digital competences (which refer to the digital characteristics of each teaching speciality) and professionalism-based digital competences (broad digital characteristics that teachers need in their teaching). Finally, Krumsvik (2011, 2014) proposed a teacher's digital competences model, founded on a double ICT user facet, but in the education context and based on four dimensions: basic ICT skills (handling ICT), didactic ICT competences (using ICT in the subject matters taught), learning strategies (using ICT in the education context) and digital Bildung (ethical and moral reflections on ICT use).

Based on the three sets above, two large subsets can be explicitly indicated which frame the ICT competence framework among teachers, technological competences and pedagogical competences, as other research works have suggested (Baylor & Ritchie, 2002; Evaluation and Accountability of Department of Education and Training of Western Australia [EADETWA] 2007; Law, 2009; Law & Chow, 2008; Orellana, Almerich, Suárez-Rodríguez, & Belloch, 2013; Pelgrum, 2009a; Suárez-Rodríguez, Almerich, Gargallo, & Aliaga, 2013).

Pedagogic competences refer to the series of knowledge and skills that teachers have and which allow them to suitably employ technological resources in curricular designs and professional development, and in planning their own teaching and classroom organisation (Suárez-Rodríguez, Almerich, Díaz-García, & Fernández-Piqueras, 2012). From a general viewpoint, the dimensions considered in the various proposals are summarised as: a) guidelines for the teaching-learning process according to ICT (organising the classroom, materials, the resources to use, etc.); b) constructing enriched learning environments where ICT have been completely integrated; c) communication with the education community (parents, students, etc.) through ICT; d) professional development, participation in projects and innovation where ICT are the central focal point; and e) the social, ethical, legal and human problems that derive from ICT use.

Technological competences can be understood as the series of knowledge and skills that teachers have and which allow them to adequately master various technological resources needed for their teaching practice (Suárez-Rodríguez et al., 2012). The basic aspects contemplated in this area are summarised as so: a) basic technology terminology; b) handling and using a computer (using an operative system, hardware, etc.); c) basic computer applications (word processor, spreadsheet and databases); c) multimedia applications; d) multimedia presentations; e) documental bases; f) educational software; g) Internet-related technology; e.g. browsing, communication (email, forums, Chat, etc.), information searches, virtual learning environments, Web 2.0 and creating web pages.

1.2. An ICT competences model for teachers

This section presents the ICT competence model for teachers according to two competence-based components, technological and pedagogical, and to personal and contextual factors.

1.2.1. Teachers' ICT competences and their relation

Okojie et al. (2006) point out that the relation between technology and pedagogy has not been sufficiently studied. Very few studies have dealt with the relation between technological competences and pedagogical ones (Markauskaite, 2007). Besides, works have focused fundamentally on technological competences and have, to an extent, placed pedagogical ones in second place (Galanouli, Murphy, & Gardner, 2004; Sandholtz & Reilly, 2004). So it is necessary to conduct studies that examine the interrelation between these two competence domains: technological and pedagogical.

Therefore the ICT competence model for teachers being considered −see Fig. 1 comprises two areas of competences −technological and pedagogical-which, in turn, are composed of four dimensions, for which details are provided below (see

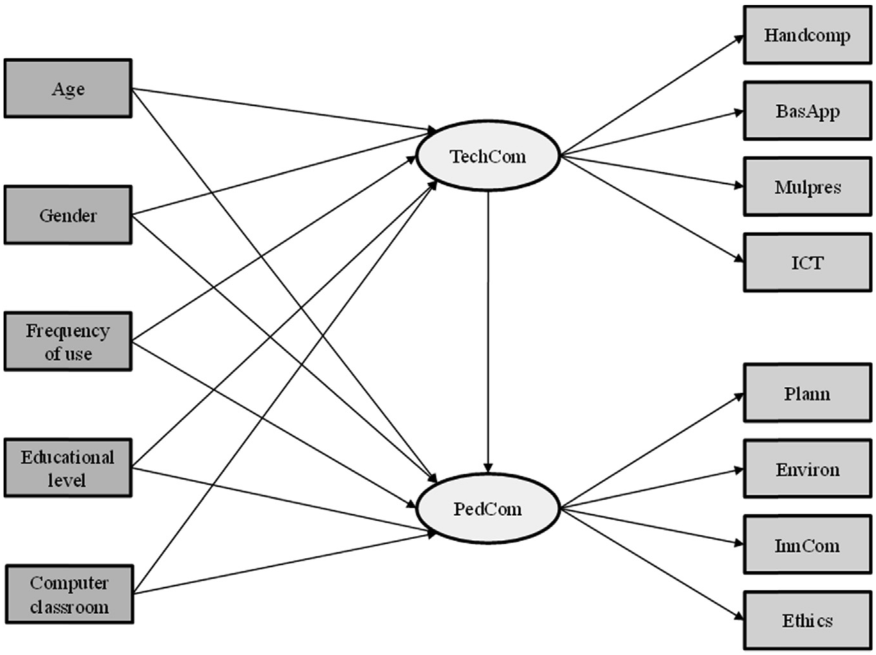

Fig. 1. Teachers' ICT competence model.

Fig. 2). In line with this,Suárez-Rodríguez et al. (2012) demonstrates that although both competence types are two clearly separate areas, they form a single set. Markauskaite (2007) indicate that cognitive and technological capacities are two separate, yet significantly correlated components.

Besides, it has been suggested that the pedagogical competences in the model are influenced by the technological ones. Ertmer and Ottenbreit-Leftwich (2010) point out that although technological competences do not suffice to integrate ICT into classrooms, they are actually required for this very purpose. Mooij and Smeets (2001) indicate that if teachers do not trust their skills or competences to handle computers, they may be unwilling to introduce technology into their classroom. Similarly, Condie and Munro (2007) demonstrate that in the first stages of ICT teacher training, the technological part is more important, but later the pedagogical part predominates. Inan and Lowther (2010) point out that technological competence is the main indicator of how prepared teachers are for integrating ICT. Kennisnet (2012) points out that the basis of the pedagogical component is ICT basic skills. Dong et al. (2015) found that technological knowledge was a predictor of both technological content knowledge and technological pedagogic knowledge which, in turn, are predictors of TPACK. Consequently, teachers' knowledge of technological resources is fundamental for ICT to be subsequently integrated into classrooms (Ertmer & Ottenbreit-Leftwich, 2010; Kennisnet, 2012).

1.2.2. Personal and contextual factors in ICT competences

One of the main aspects to understand ICT integration lies in a complex process in which several factors intervene (Angeli & Valanides, 2013; Guzman & Nussbaum, 2009; Inan & Lowther, 2010; Karaca et al., 2013; Okojie et al., 2006).

Several authors (Drent & Meelissen, 2008; Ertmer, 2005; Inan & Lowther, 2010; Karaca et al., 2013; Law, 2009; Mumtaz, 2000; Ritzhaupt, Dawson, & Cavanaugh, 2012) state that there are factors which influence the integration of these technological resources. Basically, and in accordance with Ertmer's proposal (1999), we distinguish between the contextual factors surrounding teachers, or first-order factors, and teachers' personal factors, or second-order factors.

Studies into ICT competences suggest that a series of influential personal and contextual factors exists, such as gender, age, frequency of using a computer at home, level of education taught, and there being a computer available in the workplace. At the univariate level, that is, considering each factor separately, differences have been found in each one. Indeed, gender is a differentiating factor between male and female teachers as male teachers display a higher level of competences than their female counterparts (Almerich et al., 2005, 2006; EADETWA, 2007; Papanastasiou & Angeli, 2008; Russell, Finger, & Russell, 2000; Sipilä, 2014; Suárez, Almerich, Gargallo, & Aliaga, 2010; Suárez et al., 2012; Tejedor & García-Valcárcel, 2006). Age indicates that younger teachers have a better level of both technological and pedagogical competences than teachers of more advanced age (Almerich et al., 2005; Almerich, Suárez, Belloch, & Orellana, 2010; Almerich, Suárez, Orellana, & Díaz, 2010; EADETWA, 2007; Fraillon, Ainley, Schulz, Friedman, & Gebhardt, 2014; Russell et al., 2000; Suárez et al., 2010; Suárez-Rodríguez et al., 2012). The frequency of using a computer at home factor has an impact on teachers' competences (Fraillon et al., 2014; Suárez-Rodríguez, 2012). As far as level of education taught is concerned, only studies on non-university teachers have been considered and highlight that there are fewer competences in primary education than at the other two

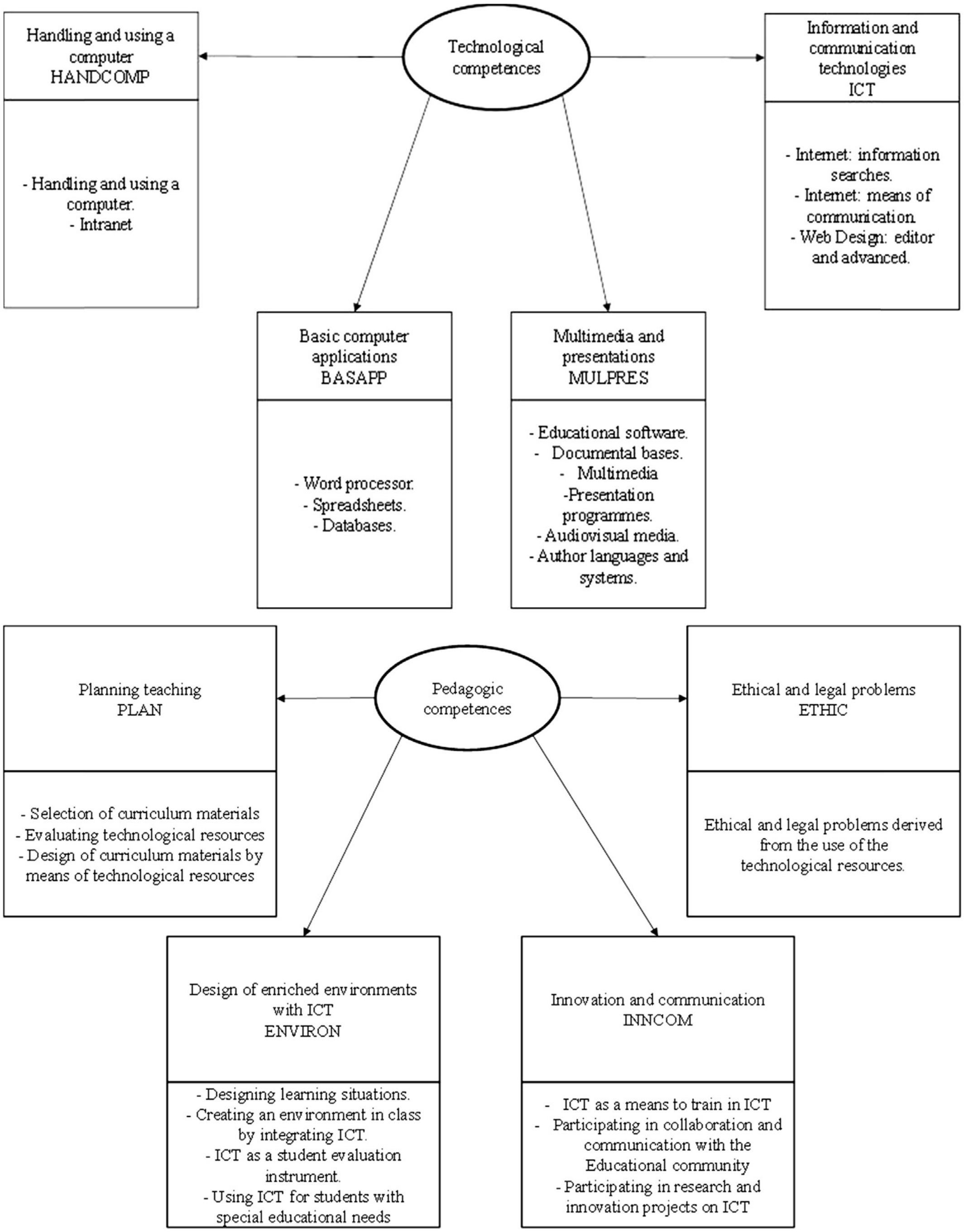

Fig. 2. The ICT competences dimensions.

levels of education, where they are similar (Almerich et al., 2005, 2006; EADETWA, 2007; Hsu, 2010; Suárez-Rodríguez et al., 2012; Tejedor & García-Valcárcel, 2006). Finally, the teachers with a computer available in the workplace factor influences ICT competences (Almerich, Suárez, Belloch, et al., 2010; Suárez-Rodríguez et al., 2012).

At the multivariate level, very few studies have been done, and those that exist stress that the relation between various factors is more complex (Law & Chow, 2008; Suárez-Rodríguez et al., 2012). Gender is a good example. It has been observed that ICT competences at the univariate level clearly distinguish male teachers from female teachers (Suárez-Rodríguez et al., 2012). At the multivariate level however, this statement becomes more specific because it has been found that female teachers are more closely linked to pedagogical competences than male teachers, who are more closely linked to technological ones (Orellana et al., 2013; Suárez-Rodríguez et al., 2013). One the other hand, the frequency of using a computer factor influences technological competences (Karaca et al., 2013; Orellana et al., 2013; Suárez-Rodríguez et al., 2013). A computer room, or the classroom being equipped with technological resources, implies a higher level of competences (Orellana et al., 2013; Suárez-Rodríguez et al., 2013), which coincide with use (Inan & Lowther, 2010; Ritzhaupt et al., 2012). Finally, age has not been found to be a significant factor for competences (Orellana et al., 2013; Suárez-Rodríguez et al., 2013). However, Inan and Lowther (2010) observe its significance for computer competences, but not for teachers' preparation, while Vanderlinde et al. (2014) state that age is not significant for computer use.

For this reason, and given the complexity of integrating ICT into the proposed model, the personal and contextual factors (gender, age, frequency of using a computer at home, level of education taught and using a computer classroom) were considered to affect both competence types, as seen in Fig. 1.

1.3. Study aim

The aim of the present study was to build a basic ICT competences model for all teachers, from Primary Education to Higher Education, in order to know if this model is stable at all levels of education. To this end, technological and pedagogical competences were considered. Besides, another series of personal and contextual factors was introduced, which along with the two above-cited variables, established the relational structure of the whole series. This was also contemplated from a multivariate perspective given the existence of several factors linking them, as other authors have suggested (Law & Chow, 2008; Suárez et al., 2010; Tondeur, Valcke, & van Braak, 2008).

This will enable the broader integration of ICT into the education domain and the development of training plans that better adapt to teacher requirements.

2. Material and methods

2.1. Research design

This is a study of secondary data analysis (McMillan & Schumacher, 2010) based on data from two research works into teachers, which both used a survey design. In this study, based on the two previous projects, has been carried out a data re-examination to support models of innovation-integration in the process of teaching and learning within a research project focused on learning-centred methodologies.

2.2. Participants

The study sample was made up of male and female teachers who worked in Primary Education and Secondary Education schools and Universities in the Valencian Community.

The non-university teachers included in the study sample were selected by stratified random sampling, according to level of education taught and province in the Valencian Community. The primary sampling unit was education centres, and the secondary unit was the teachers who completed the questionnaire. The university teaching sample, which came from four universities in the Valencian Community (Universidad de Valencia, Universidad Politécnica de Valencia, Universidad de Alicante and Universidad Jaume I de Castellón), was obtained by stratified random sampling in which the following marker variables were considered: university, gender, occupational situation and specialised area.

The sample was made up of 1095 male and female teachers. According to the key personal and contextual variables, sample distribution was summarised as:

a The gender distribution of the whole sample was approximately 48.3% of male teachers and 51.7% of female teachers.
b Teachers' age distribution ranged from 20 to 69 years, with a mean age of 41.3 years.
c Distribution according to level of education taught was in accordance with gender: 32.1% of the teachers taught Primary Education, of whom 34.8% were male and 65.2% were female; 31.9% taught Compulsory Secondary Education, of whom 52.0% were male and 48.0% were female; 18.4% taught Upper Secondary Education, of whom 56.3% were males and 43.7% were females; 17.6% were University teachers, and 64.6% were males and 35.4% females.
d Teachers' professional experience fell within a range from 1 year to 45 years, with average professional experience being 15.3 years.
e To help contextualise sample characteristics, it is necessary to point out that among the teachers surveyed; frequency of using a computer at home was 14.6% once or twice a month, 23.7% several times a month or weekly, 30.0% several times a week, and 31.6% on a daily basis.
f Finally, 49.2% of the teachers did not have regular access to the computer classroom, while 51.8% of the sample did.

2.3. Data collection instrument

The data collection instrument used was the questionnaire, which was designed expressly for this purpose and contains eight sections: teacher characteristics; access to computer equipment; knowledge of ICT; use of ICT (personal-professional and with students); ICT integration into educational practice; training requirements in both technological resources and ICT integration; attitudes to ICT; obstacles for using them in class.

When designing the questionnaire, firstly the different ICT references among teachers were taken into account to establish a theoretical ICT competence model for teachers. This way, the following proposals were considered: ISTE (2002); the Department of Education of Victoria (1998); the North Caroline Department of Public Instruction (2000). Then the questionnaire was sent to several experts in educational technology for them to evaluate the items. According to the experts' judgements, and after considering their suitability, the definite instrument was created.

This study centred on teachers' ICT competences which form part of two sections in the questionnaire: knowledge of ICT and ICT integration. Both sections were evaluated on a 5-point Likert scale.

The knowledge of ICT section (see Fig. 2) consisted in 32 items (Cronbach's $\alpha = 0.98$) and was divided into four basic dimensions: handling and using a computer (6 items); basic computer applications (7 items); multimedia applications and presentations (12 items); the ICT dimension (7 items). In each dimension, items indicated teachers' knowledge of certain operations, which were progressively arranged so that the first items corresponded to the most basic knowledge and the last items to the most advanced knowledge of technological tools. The 5-point scale went from nothing to a lot.

The ICT integration section (see Fig. 2) comprised 11 items (Cronbach's $\alpha = 0.92$), in which teachers were asked about how they integrate ICT into their curricular design and development and into their educational Planning and Organisation. This section had four dimensions: Planning teaching; creating environments from where ICT are integrated; communication with the school community; ethical aspects. The 5-point scale went from never to always.

To arrange these indicators in the dimensions, a decision was made to establish item parcels as a work tool given the circumstances of this particular situation. Both the scale on which indicators were measured, a 5-point Likert scale in both cases (Schau, Stevens, Dauphinee, & Vecchio, 1995), and the fact that there were clear associations of "difficulty" among elements (Rushton, Brainerd, & Pressley, 1983), constituted a complex structure that, as we see it, does not help arrange this field straightforwardly. Therefore, each item parcels is the mean of the items that compose it (Kishton & Widaman, 1994).

2.4. Data analyses

The statistical analyses were done using descriptive statistics, which were obtained with the SPSS 19.0 programme, and were modelled by structural equations with the LISREL 8.80 programme.

In order to validate the model, a Multiple Indicators and Multiple Causes Model (MIMIC) (Joreskog & Goldberger, 1975; Muthén, 1989) was used to deal with the complexity of the situation, particularly when different covariate variables were involved, and a mixture of different levels of measures emerged from continuous to nominal. The MIMIC model, a particular type of SEM model (Schumacker & Lomax, 2010), is composed of one or more latent variables that represent the constructs, and several observed variables that are related to these latent variables (Joreskog & Goldberger, 1975). In this model, the observed variables represent both the indicators of the latent variable and the causes that predict this variable (Joreskog & Goldberger, 1975; Muthén, 1989; Schumacker & Lomax, 2010). Therefore, latent variables intervene between the two types of observed variables (Muthén, 1989), indicators and causes. Furthermore, both the latent variables and indicators are predicted from a set of causes or explanatory variables. These explanatory variables play the role of covariates of both the latent variable and indicators of the model (Muthén, 1989), determining the direct effect on these (Brown, 2006). Thereby, the MIMIC model is composed of two parts: a measurement component and a structural component (Schumacker & Lomax, 2010; Wang & Shih, 2010). The indicators determine the latent variable at the measurement component, while the causes or explicative variables predict the latent variable in the structural component (Schumacker & Lomax, 2010). Muthén (1989) points out that the structural component provides extra information about the measurement component, allowing validation of construct and invariance across subpopulations. Besides, the structural component provides a greater strength to the dimensionality of the construct and allows the detection of sources of heterogeneity on the population (Muthén, 1989). The MIMIC model offers advantages over multiple-sample analysis, since the required sample size is smaller (Kline, 2010; Brown, 2006) because the sample is not partitioned in subsamples (Kline, 2010). On the other hand, the MIMIC model is more parsimonious when three or more groups are compared (Brown, 2006). The MIMIC model has been used to address multiple problems: analysis of between-group differences in the latent variables (Kline, 2010; Thompson & Green, 2006); construct validation (Brown, 2006); assessing differential item functioning – DIF- (Wang & Shih, 2010); and, in educational technology, Teo, Milutinović, and Zhou (2016) have used the MIMIC model for understanding pre-services teachers' attitudes toward use of computers. Finally, another approach of MIMIC model arises from formative and reflective measurement models for construct validation (Diamantopoulos & Winklhofer, 2001; Posey, Roberts, Lowry & Bennett, 2014).

Model estimations were made by the robust maximum likelihood procedure given the non-normality nature of the dimensions used (see Table 1). For the model fit evaluation, and owing to the procedure followed, an adjusted Satorra-Bentler χ^2 test was used. Besides, several authors (Byrne, 2006; Mueller & Hancock, 2010) recommend using other indicators to evaluate fit. We followed several recommendations and selected the following: Root Mean Square Error of Approximation (RMSEA), with a value of below 0.05 being a good fit value, plus its 90% confidence interval and its likelihood; Comparative fit

Table 1
Descriptive statistics of teachers' competences.

	Dimensions	Univariate descriptive statistics					
		Mean	Stand. Dev.	Distribution shape		Normality test with skewness and kurtosis	
				Skewness	Kurtosis	Chi square	*p*-Value
Technological competences	Handcomp	2.84	1.14	0.24	−1.01	67.41	0.000
	Basapp	2.94	1.16	0.08	−0.98	53.15	0.000
	Mulpres	2.06	0.96	0.92	0.06	136.12	0.000
	ICT	2.72	1.17	0.14	−1.06	64.71	0.000
Pedagogical competences	Plann	2.88	1.09	−0.18	−0.73	35.75	0.000
	Environ	2.08	0.95	0.70	−0.16	88.05	0.000
	Inncom	2.07	0.94	0.75	−0.02	98.81	0.000
	Ethics	2.84	1.51	0.09	−1.43	112.25	0.000

index (CFI), for which fit indices over 0.95 were considered a good fit; Standardised Root Mean Square Residual (SRMR), with values under 0.05 indicating a good model fit; and Goodness-of-Fit Index (GFI) and Adjusted Goodness-of-Fit Index (AGFI), with values above 0.90 indicating acceptable model fit.

2.5. Procedure

The data in the questionnaires in both cases were collected mainly by online questionnaires. Teachers were contacted and offered the chance to complete the questionnaire online or to send a completed printed copy of it. Most teachers completed the questionnaire online, although due to lack of either facilities or teachers' knowledge, some were completed as a printed questionnaire and were posted.

3. Results

The results are arranged in two parts. The first part describes the teachers' technological and pedagogical competences. The second describes the teachers' basic ICT competences model.

3.1. Descriptive analysis of teachers' ICT competences

Generally speaking, teachers' competences are limited by their level, as Table 1 shows. It can also be stated that the level of technological competences is higher than that of pedagogical ones, as seen in the eight study dimensions. The variability found suggests there are teachers with an advanced level of competences and others with a basic level, and that the second category comprises a larger number of teachers, as the indices show in distribution terms.

Teachers are seen to have a normal user level of technological competences; that is, they master technological resources, but not advanced options; hence they can handle and use computers, basic computer applications, and ICT. Knowledge, however, in the multimedia applications and presentations dimension is somewhat basic, and teachers have their limitations and gaps in different resources.

In the pedagogical competences, teachers contemplate the Planning your teaching and Ethics dimensions, but not habitually, just occasionally. Furthermore, the high level of heterogeneity found stresses that teachers are more concerned about ICT for their day-to-day practice. The creation of an ICT-enriched learning environment, the innovation-training with ICT facet and communication with the education community are considered sporadically.

The correlations among the dimensions (see Table 2) indicate that the technological competences dimensions show a strong relation among them, and the same can be said of the pedagogical competences dimensions. Conversely, the correlations between the technology and the pedagogical competences obtain lower values. It is worth indicating that the Ethics dimension correlates the least with the other dimensions, especially in technological competences.

The relation between the covariate variables and dimensions shows that gender, frequency of using a computer at home and level of education taught obtain a higher value with dimensions, particularly in technological competences. In pedagogical competences, the value of these variables lowers substantially, especially for gender and level of education taught. Using a computer classroom and age obtain lower values, although they are slightly higher in the pedagogical competences.

The relations between covariate variables and dimensions demonstrate that male teachers better master technological resources than their female counterparts, and to a lesser extent than with the pedagogical dimensions. For frequency of using a computer, it is seen that the greater its use, the higher the level of competences, above all in the technology domain. Level of education taught indicates that the higher the teachers' level of knowledge, the higher their level of technological resources, but not in pedagogical competences. Using a computer classroom has an impact on the level of competences, preferentially with the pedagogical dimensions. Finally, age shows that the younger teachers are, the better they master ICT competences.

Table 2
Correlations between dimensions and covariates.

	Handcomp	BasApp	Mulpres	ICT	Plann.	Envir.	Inncom	Ethics	Gender	Age	Frequency of use	Educational level	Computer classroom
Handcomp	1.00												
BasApp	0.85	1.00											
Mulpres	0.79	0.78	1.00										
ICT	0.83	0.80	0.82	1.00									
Plann.	0.57	0.59	0.59	0.59	1.00								
Environ.	0.51	0.52	0.58	0.54	0.76	1.00							
Inncom	0.52	0.53	0.61	0.55	0.70	0.82	1.00						
Ethics	0.33	0.35	0.36	0.34	0.54	0.48	0.52	1.00					
Gender	−0.50	−0.38	−0.32	−0.39	−0.15	−0.14	−0.16	−0.15	1.00				
Age	−0.14	−0.16	−0.17	−0.23	−0.17	−0.17	−0.14	−0.07	−0.13	1.00			
Frequency of use	0.56	0.56	0.50	0.55	0.39	0.32	0.32	0.26	−0.30	−0.07	1.00		
Educational level	0.36	0.40	0.35	0.40	0.29	0.18	0.21	0.16	−0.29	0.07	0.39	1.00	
Computer classroom	0.20	0.21	0.16	0.19	0.21	0.26	0.24	0.15	−0.03	−0.21	0.08	−0.11	1.00

3.2. Teachers' basic ICT competences model

This section presents the basic model that outlines the ICT competences of teachers from Primary Education to University Education. As mentioned earlier, a Structural Equations model of Multiple Indicators and Multiple Causes (MIMIC) was used, which showed the relation between the two ICT competences used by teachers −technological ones influence pedagogical ones- and the impact of the personal and contextual variables on the two latent variables. The covariate variables considered were: age, gender, frequency of using a computer at home, level of education taught and using a computer classroom.

In this case, the fit indicators of the proposed MIMIC model clearly reveal its relevance. Indeed all the indicators considered indicate an excellent fit (see Table 3). The $\chi 2$ adjusted by the Satorra-Bentler method is not significant, and all the other considered indicators (RMSEA, CFI, SMSR, GFI, and AGFI) suggest adequate model fit.

First of all in the measure model, the indicators of the eight dimensions are suitable to structure both the latent variables (technological competences and pedagogical competences). As Fig. 3 illustrates, all the indicators are significant ($p < 0.01$), and the standardised saturations of each one exceed the value of 0.80, except for the Ethics dimension, whose standardised saturation is 0.57. Likewise, if the correlations squared of the indicators are considered, their values go from 0.70 to 0.85, which means that the variance explained by each indicator is excellent, except for the Ethics dimension that has a value of 0.33. Therefore, the indicators included are congruent and consistent to structure the latent variables, and an adequate, significant fit is offered to explain the structural model.

A significant relation between both competence types (technological and pedagogical) is found with the structural model, which standardised value is 0.77 ($p < 0.01$). In addition, the model explains 54% of the variance in the technological component and 52% in the pedagogical component—see Fig. 3 and Table 4. Consequently, the basic structural model supports the relevance of the relation between both competence types, and the relation of the influence of technological competences versus pedagogical ones.

Regarding the effects of the covariate variables on the latent variables (see Fig. 3), according to the direct effects, except age, all the variables have an influence. Gender is significant for both technological and pedagogical competences. In the former, male teachers present a higher level and a lower level of knowledge of technological resources and pedagogical competences than female teachers, respectively. Frequency of using a computer at home implies an increase for technological competences, which is not significant for pedagogical competences. A significant relation is observed between level of education taught and technological competences. In this way, we can see that the higher the level of education taught by teachers, the more knowledge teachers have of the various technological resources. Finally, using a computer classroom implies increased ICT knowledge, and this increase is slightly higher in technological competences than in pedagogical ones.

If we consider the total effects of the covariate variables on the latent variables, we can see that all the other variables except age are significant ($p < 0.01$). Gender, frequency of using a computer and level of education taught obtain higher values in technological competences, but they lower in their relation with pedagogical competences, especially gender and frequency of using a computer, while level of education taught barely shows variation. Conversely, the opposite occurs with using a computer classroom, which is more significant in pedagogical competences. Consequently, it can be stated that male

Table 3
Indicators of the MIMIC model fit.

χ^2_{S-B}			RMSEA			CFI	SRMR	GFI	AGFI
χ^2_{S-B}	g.l.	p	RMSEA	90% int	Pclose				
32.22	59	1.0	0.00	0.00–0.00	1.00	1.0	0.031	0.94	0.91

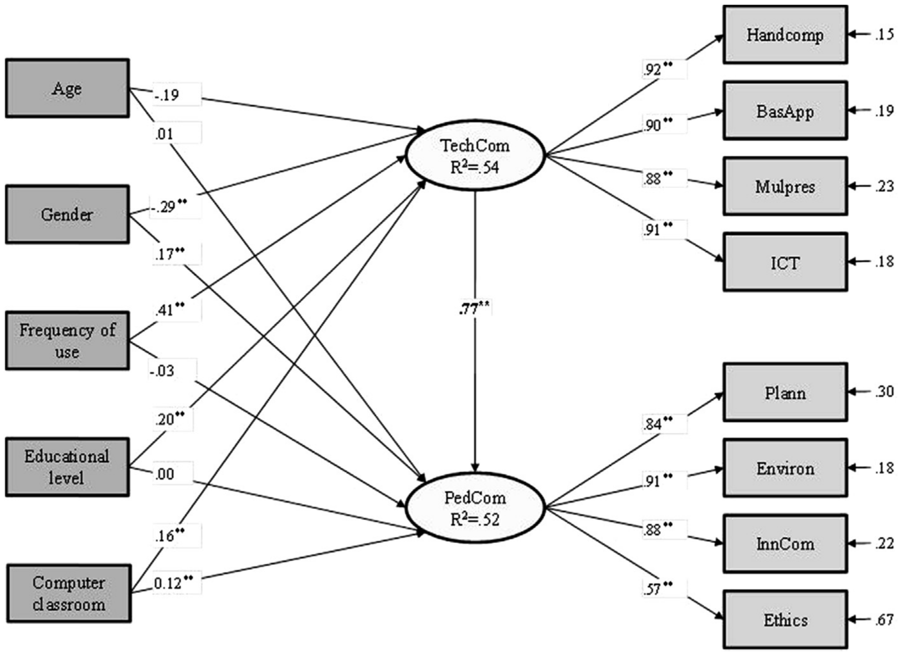

Fig. 3. Standardised multiple indicators and multiple causes model.

teachers have more knowledge about technological resources than female teachers, while the opposite occurs in pedagogical competences. Frequency of using a computer shows a general increase in competences, which is higher for technological knowledge. Both competence types increase for level of education taught at the various system levels. Finally, using a computer classroom shows a generalised increase in competences, although it is higher for those of a pedagogical kind.

The pattern of influences of the indirect effects of the covariate variables on the competence dimensions is the same as that described for partial effects. The indirect effects in the four significant variables are strong, especially gender and frequency of using a computer. This results in the influence that technological competences have on the pedagogical ones more consistently and specifically since these are the two most influential variables in the former type.

4. Discussion

The obtained results have allowed us to state that our teachers (Primary Education, Secondary Education and Universities) have their limitations in ICT competences. Such difficulties appear in pedagogical competences in particular, where the mean values are lower, and these results agree with other research works (Sipilä, 2014).

Our teachers show a normal level of handling and using computers, basic computer applications and ICT applications, which it is consistent with other research (Alba & Carballo, 2005; Fraillon et al., 2014; Tezci, 2010; Sipilä, 2014; Wastiau et al., 2013). These results are obtained irrespectively of the level of education taught, where browsing through an operative system, using a word processor, the Internet to search for information and email are the resources that teachers know best. This

Table 4
Standardised effects of covariate variables on latent variables.

	Covariates	Direct effect	Indirect effect	Total effect
Technological competences	Gender	−0.29**		−0.29**
$R^2 = 0.54$	Age	−0.19		−0.19
	Frequency of use	0.41**		0.41**
	Educational level	0.20		0.20**
	Computer classroom	0.16**		0.16**
Pedagogical competences	Gender	0.17**	−0.23**	−0.06**
$R^2 = 0.52$	Age	0.01	−0.14	−0.13
	Frequency of use	−0.03	0.31**	0.28**
	Educational level	0.00	0.16**	0.16**
	Computer classoom	0.12**	0.12**	0.24**

(*= $p \leq 0.05$, **= $p \leq 0.01$).

enables us to state that the level of technological knowledge is generally basic (Almerich, Suárez, Orellana, et al., 2010; Suárez et al., 2010).

Teachers tend to use pedagogical competences occasionally rather than regularly. Planning education is where this activity becomes more regular, which is in line with what other research has indicated (Alba & Carballo, 2005; Empirica, 2006; Wastiau et al., 2013). Teachers tend to generally bear in mind ethical and legal problems when using ICT. They rarely consider creating environments where ICT have been integrated into daily teaching-learning process practices, which is most likely due to the infrastructures found in classrooms. Teachers scarcely use new resources for their professional development and to communicate with the education community, as found Wastiau et al. (2013).

Based on the results obtained, the basic ICT competences model for teachers giving classes at all levels of education has been validated. Firstly, the measure indicators considered in both the technological and pedagogical competences are appropriate for the model, which means that the eight basic dimensions considered suitably integrate into the competence frameworks assumed.

Secondly, the findings reveal that technological competences strongly influence pedagogic competences, and that they act as the antecedents required to develop pedagogical competences since the former are precursors of the latter. Other recent research works, such as Inan and Lowther (2010) or Chai (2010), found the same effect because they discovered a consistent positive relation between both constructs. Furthermore, Fraillon et al. (2014) found that technological competences involve more use with students.

Thirdly, the introduction of personal and contextual factors into the model indicates a more in-depth approach to the complex nature of ICT in education. In this way, the obtained results indicate that gender, frequency of using a computer at home, level of education taught and having access to a computer clasroom are the four most important factors in the model employed.

Frequency of using a computer at home and level of education taught relate significantly with technological competences. The first of the two is the factor which has more influence on the series of competences. Conversely, no evidence for a direct effect on pedagogical competences is observed, although a significant indirect effect on these competences is found, be it to a lesser extent. Access to a computer classroom and gender are the two factors seen to have considerable influence on both competence types. So it can be stated that university teachers, who frequently use technological resources at home, know them better, unlike female Primary Education teachers who present a less knowledge of this kind. Presence of technological resources in classrooms implies a higher level of competences. Finally, age does not come over as a significant factor in the model, which corroborates those studies suggesting that other factors can better explain this effect attributed to age (Law & Chow, 2008). Therefore, all the findings in the present work coincide with previous works at both the univariate and multivariate levels (Hsu, 2010; Karaca et al., 2013; Law & Chow, 2008; Papanastasiou & Angeli, 2008; Suárez-Rodríguez, et al., 2013).

The model has allowed us to obtain solid evidence for the relation established between the two areas of competences and provides highly relevant specifications. Thus, male teachers have more knowledge of technological resources in technological competence, while female teachers consider implementing pedagogical competences more than their male counterparts. This effect may be due, at least in part, to the relation between the level of education taught and the gender of teachers; so further studies would be desirable.

5. Conclusions

The first study objective was to validate an ICT competences model for teachers. Based on the obtained results, a basic and essential model of ICT competences was validated. Therefore, this model is an advance regarding the empirical validation of competence frameworks that Tondeur et al. (in press) advocate and it is also a response to the lack of definition of teachers' ICT competences that Hall et al. (2014) put forward.

Besides, teacher's ICT competences form a set of knowledge and skills that, in turn, form two subsets: technological competences and pedagogical competences. These two subsets are linked asymmetrically and in such a way that technological competences influence pedagogical competences. This coincides with what Aesaert and van Braak (2015) considered about ICT competences being a multilayered unit, and that technological knowledge and skills are included in the model. Moreover, these two subsets are connected asymmetrically, so that the technological competences influence on pedagogical competences. Similar conclusions are obtained by Dong et al. (2015) for whom the technological component influences on pedagogical component. Therefore, technological competences constitute the basis of the pedagogical competences, and the teacher has to master the first to implement the second, as Kennisnet (2012) proposed.

The second objective was to know if the basic model would serve all teachers at all levels of education. The results indicated that the model offers stability and is representative of teachers, irrespectively of the level of education they teach, and a basic ICT competences structure is maintained. Consequently, these results corroborate that existing competence frameworks can be taken as a reference for teachers' professional development, irrespectively of the level of education they teach, provided the two competence subsets are considered. It's a respond to the proposal of UNESCO (2011).

The third objective was to know whether the contextual and personal factors have an impact on the model. As we have seen, these factors imply a complex relation between ICT competences and teachers, which reinforces the consideration that competences imply complexity, which was what Aesaert and van Braak suggested (2015).

Thus the model presented and validated herein contributes, on the one hand, the theoretical scheme of ICT competences (the subsets and dimensions that form it) and its validation based on the empirical evidence obtained from the questionnaire designed for this purpose. Hence this model of competences may, on the other hand, also help define indicators of ICT competences for teachers in these educational resources to be used for assessing and monitoring the ICT integration process, which is in line which what Pelgrum suggested (2009a, 2009b). Besides, these competence indicators could be used for assessing the progress of other models that use ICT, as proposed by Bilbao-Osorio and Pedró (2009). It could also be a reference for teachers in training (Tondeur et al., in press).

ICT competences are key elements in terms of the use that teachers confer them and their training in them. Regarding their use, Chai (2010) found a significant relation between ICT competences and their constructivist use by teachers, and stated that ICT competences are the basis for their use by teachers in classrooms. Chen (2010) also found a relation between teachers' use of and skills in ICT, along with the perception of an ICT training programme. Wastiau et al. (2013) also found a positive relationship between students' use of ICT with teachers' ICT competences. Regarding the relation between use and competences, this competences model allowed the dimensional structuring of teachers' ICT competences and the academic use of these educational resources by teachers (Almerich, Suárez, Orellana, et al., 2010), and in such a way that technological competences are linked with personal-professional use, and pedagogical competences are linked with students' use of them in the classroom. This adds a distinctive joint view of the relation found in other research works.

One key aspect to help teachers develop competences with their students is to train teachers in ICT competences (Voogt, Erstad, Dede & Mishra, 2013). In this way, the teacher training programmes that public administrations develop need to integrate both the technological and pedagogical components (Law, 2009; Voogt, Knezek, et al., 2013; Voogt, Fisser, et al., 2013; Voogt, Erstad, et al., 2013). Nevertheless, the obtained results reveal that each level of education presents different levels of technological and pedagogical competences. Therefore any training plan that intends to encourage greater integration of ICT into teaching practices needs to consider these circumstances if it intends to confront this objective efficiently. This guides us towards flexibility in future professional development plans by adapting to the level of teaching, just as the reviews made on teacher training in ICT consider (Galanouli et al., 2004), as do the results by Almerich et al. (2011), found in relation to the hierarchy of the teacher training requirements in such matters. It is also necessary to consider that ICT competences are closely related to training requirements (Almerich et al., 2011; Wastiau et al., 2013), and that both series are closely related to ICT integration in education (Vanderlinde et al., 2014). Moreover, training plans have to also consider the complexity of technology because the process during which teachers adopt technology depends on this variable (Aldunate & Nussbaum, 2013).

Regarding study limitations, this study was conducted in a Spanish Autonomous Community, the Valencian Community, which implies conducting similar studies to corroborate the results found, be it from the same level of education or considering them collectively. This would allow the reinforcement of a stable competence model, thus research into ICT competences should address this aspect.

Future research needs to extend and relate the basic competence model presented herein within institutional frameworks (ISTE, 2008; UNESCO, 2011) and with new proposals, such as ICT-TCPK (Angeli & Valanides, 2009), TPCAK (Koehler & Mishra, 2005), TPACK- Practical (Ay et al., 2015), and any other proposal put forward (Guzman & Nussbaum, 2009; Hsu, 2010; Krumsvik, 2014; Ottestad et al., 2014). In any case, and in agreement with Angeli and Valanides (2013), it is necessary to address the theme from the perspective of competences for teaching as a more robust and reliable form of evaluation. Within the competence frameworks, it will be necessary to consider other personal and contextual factors, such as beliefs, attitudes, facilitators and obstacles, which influence how teachers integrate resources into their classrooms (Angeli & Valanides, 2013; Chai et al., 2013). Finally, it is absolutely necessary to build ICT integration models, where both competence types are included, in order to extend other models (Inan & Lowther, 2010; Karaca et al., 2013; Ritzhaupt et al., 2012; Vanderlinde et al., 2014) in which competences have been found to act as the main agents of integration by teachers.

References

Aesaert, K., & van Braak, J. (2015). Gender and socioeconomic related differences in performance based ICT competences. *Computers & Education, 84*, 8–25. http://dx.doi.org/10.1016/j.compedu.2014.12.017.

Alba, C., & Carballo, R. (2005). Viabilidad de las propuestas para la aplicación el crédito europeo por parte del profesorado de las universidades españolas, vinculadas a la utilización de las TIC en la docencia y la investigación. *Revista de Educación, 337*, 71–97.

Aldunate, R., & Nussbaum, M. (2013). Teacher adoption of technology. *Computers in Human Behavior, 29*(3), 519–524. http://dx.doi.org/10.1016/j.chb.2012.10.017.

Almerich, G., Suárez, J. M., Belloch, C., Gastaldo, I., Orellana, N., Bo, R., & Díaz, I. (2006). *Digital divide in ICT competences in primary and secondary education: a complex relation with other key dimensions*. Open Education Europa. Retrieved from. http://www.openeducationeuropa.eu/en/article/Digital-divide-in-ICT-competences-in-primary-and-secondary-education%3A-a-complex-relation-with-other-key-dimensions.

Almerich, G., Suárez, J. M., Belloch, C., & Orellana, N. (2010). Perfiles del profesorado a partir del conocimiento de los recursos tecnológicos y su relación con el uso que hacen de estas tecnologías. *Revista Complutense de Educación, 21*(2), 247–269.

Almerich, G., Suárez, J. M., Orellana, N., Belloch, C., Bo, R., & Gastaldo, I. (2005). Diferencias en los conocimientos de los recursos tecnológicos en profesores a partir del género, edad y tipo de centro. *RELIEVE, v, 11*(2). Retrieved from http://www.uv.es/RELIEVE/v11n2/RELIEVEv11n2_3.htm.

Almerich, G., Suárez, J. M., Orellana, N., & Díaz, M. I. (2010). La relación entre la integración de las tecnologías de la información y comunicación y su conocimiento. *Revista de Investigación Educativa, 28*(1), 31–50.

Almerich, G., Suáreaz-Rodríguez, J. M., Belloch, C., & Bo, R. M. (2011). Training needs of teachers in ICT: Training profiles and elements of complexity. *RELIEVE, 17*(2), 1–28. Retrieved from http://www.uv.es/RELIEVE/v17n2/RELIEVEv17n2_1eng.htm.

Angeli, C., & Valanides, N. (2005). Pre-service teachers as ICT designers: an instructional design model based on an expanded view of pedagogical content knowledge. *Journal of Computer-Assisted Learning, 21*(4), 292–302. http://dx.doi.org/10.1111/j.1365-2729.2005.00135.x.

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: advances in techonological pedagogical content knowledge (TPCK). *Computers & Education, 52*(1), 154–168. http://dx.doi.org/10.1016/j.compedu.2008.07.006.

Angeli, C., & Valanides, N. (2013). Technology mapping: an approach for developing technological pedagogical content knowledge. *Journal of Educational Computing Research, 48*(2), 199–221. http://dx.doi.org/10.2190/EC.48.2.e.

Ay, Y., Karadağ, E., & Acat, M. B. (2015). The Technological Pedagogical Content Knowledge-practical (TPACK-Practical) model: examination of its validity in the Turkish culture via structural equation modeling. *Computers & Education, 88*, 97–108. http://dx.doi.org/10.1016/j.compedu.2015.04.017.

Baylor, A. L., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classroom? *Computers & Education, 39*(4), 395–414. http://dx.doi.org/10.1016/S0360-1315(02)00075-1.

Bilbao-Osorio, B., & Pedró, F. (2009). A conceptual framework for benchmarking the use and assessing the impact of digital learning resources in school education. In F. Scheuermann, & F. Pedró (Eds.), *Assessing the effects of ICT in education: Indicators, criteria and benchmarks for international comparisons* (pp. 107–118). Paris: European Union/OECD.

Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. New York: The Guilford Press.

Buabeng-Andoh, C. (2012). Factors influencing teachers' adoption and integration of information and communication technology into teaching: a review of the literature. *International Journal of Education and Development using Information and Communication Technology, 8*(1), 136–155.

Byrne, B. M. (2006). *Structural equation modelling with EQS. Basic concepts, aplications and programing* (2nd ed.). London: Lawrence Erlbaum Associates.

Chai, C. S. (2010). The relationships among Singaporean preservice teachers' ICT competencies, pedagogical beliefs and their beliefs on the Espoused use of ICT. *Asia-Pacific Education Researcher, 19*(3), 387–400.

Chai, C. S., Ng, E. M. W., Li, W., Hong, H. Y., & Koh, J. H. L. (2013). Validating and modelling technological pedagogical content knowledge framework among Asian preservice teachers. *Australasian Journal of Educational Technology, 29*(1), 41–53. http://dx.doi.org/10.1234/ajet.v29i1.174.

Chen, R. J. (2010). Investigating models for preservice teachers' use of technology to support student-centered learning. *Computers & Education, 55*(1), 32–42. http://dx.doi.org/10.1016/j.compedu.2009.11.015.

Condie, R., & Munro, B. (2007). The impact of ICT in schools- a landscape review. *Coventry: Becta research*. Retrieved from: http://dera.ioe.ac.uk/1627/1/becta_2007_landscapeimpactreview_report.pdf.

Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High access and low use of technologies in high school classrooms: explaining an apparent paradox. *American Educational Research Journal, 38*(4), 813–834. http://dx.doi.org/10.3102/00028312038004813.

Department of Education of Victoria. (1998). *Learning technology teacher capabilities*. Retrieved from:http://acce.edu.au/journal/14/2/appendix-5-learning-technology-capabilities-guide-victoria.

Diamantopoulos, A., & Winklhofer, H. M. (2001). Index construction with formative indicators: an alternative to scale development. *Journal of Marketing Research, 38*(2), 269–277. http://dx.doi.org/10.1509/jmkr.38.2.269.18845.

Dong, Y., Chai, C. S., Sang, G.-Y., Koh, H. L., & Tsai, C.-C. (2015). Exploring the profiles and interplays of pre-service and inservice teachers' technological pedagogical content knowledge (TPACK) in China. *Educational Technology & Society, 18*(1), 158–169.

Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively? *Computers & Education, 51*(1), 187–199. http://dx.doi.org/10.1016/j.compedu.2007.05.001.

Empirica. (2006). *Benchmarking access and use of ICT in European schools 2006*. Bonn: Empirica. Retrieved from http://www.empirica.de/publikationen/documents/No08-2006_learnInd.pdf.

EPICT. (2008). *EPICT sillabus*. Retrieved fromhttp://www.epict.it/sites/default/files/SyllabusModuliEPICT%5B2015%5D.pdf.

Ertmer, P. A. (1999). Addressing first- and second order barriers to change: strategies for technology integration. *Educational Technology Research and Development, 47*(4), 47–61.

Ertmer, P. (2005). Teacher pedagogical beliefs: the final frontier in our quest for technology integration? *Educational Technology Research and Development, 63*(4), 25–39.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change; how knowledge, confidence, beliefs and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255–284. http://dx.doi.org/10.1080/15391523.2010.10782551.

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: a critical relationship. *Computers & Education, 59*(2), 423–435. http://dx.doi.org/10.1016/j.compedu.2012.02.001.

Eurydice. (2011). *Key data on learning and innovation through ICT at school in Europe 2011*. Brussels: Eurydice. Retrieved fromhttp://eacea.ec.europa.eu/education/eurydice/documents/key_data_series/129EN.pdf.

Evaluation and Accountability of Department of Education and Training of Western Australia (EADETWA). (2007). Evaluation of the information and communication technology (ICT) knowledge and skills levels of Western Australian government school teachers. *Department of Education and Training of Western Australia*. Retrieved fromhttps://www.det.nsw.edu.au/proflearn/der/docs/wherenow/teachict.pdf.

Ferrari, A. (2013). *DIGCOMP: A framework for developing and understanding digital competence in Europe*. Sevilla: JRC-IPTS. Retrieved fromhttp://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=6359.

Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Gebhardt, E. (2014). *Preparing for life in a digital age: The IEA international computer and information literacy study international report*. Cham: Springer.

Galanouli, D., Murphy, C., & Gardner, J. (2004). Teachers' perceptions of the effectiveness of ICT-competence training. *Computers and Education, 43*(1–2), 63–79. http://dx.doi.org/10.1016/j.compedu.2003.12.005.

Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education, 57*(3), 1953–1960. http://dx.doi.org/10.1016/j.compedu.2011.04.010.

Guzman, A., & Nussbaum, M. (2009). Teaching competencies for technology integration in the classroom. *Journal of Computer Assisted Learning, 20*(5), 453–469. http://dx.doi.org/10.1111/j.1365-2729.2009.00322.x.

Hall, R., Atkins, L., & Fraser, J. (2014). Defining a self-evaluation digital literacy framework for secondary educators: the DigiLit Leicester project. *Research in Learning Technology, 22*(21440). http://dx.doi.org/10.3402/rlt.v22.21440. Retrieved fromhttp://www.researchinlearningtechnology.net/index.php/rlt/article/view/21440.

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: current knowledge gaps and recommendations for future research. *Educational Technology Research and Development, 55*(3), 223–252. http://dx.doi.org/10.1007/s11423-006-9022-5.

Hixon, E., & Buckenmeyer, J. (2009). Revisiting technology integration in schools: implications for professional development. *Computers in the Schools, 26*(2), 130–146. http://dx.doi.org/10.1080/07380560902906070.

Hsu, S. (2010). Developing a scale for teacher integration of information and communication technology in grades 1–9. *Journal of Computer Assisted Learning, 26*(3), 175–189. http://dx.doi.org/10.1111/j.1365-2729.2010.00348.x.

Inan, F. A., & Lowther, D. L. (2010). Factors affecting technology integration in K-12 classrooms: a path model. *Educational Technology Research and Development, 58*(2), 137–154. http://dx.doi.org/10.1007/s11423-009-9132-y.

International Society for Technology in Education. (2002). *ISTE National educational technology standards (NETS) and performance indicators for teachers*. Eugene, OR: ISTE. Retrieved fromhttp://www.iste.org/docs/pdfs/nets_for_teachers_2000.pdf?sfvrsn=2.

International Society for Technology in Education. (2008). *NETS for teachers: National educational technology standards for teachers* (2nd ed.) Retrieved fromhttp://www.iste.org/docs/pdfs/20-14_ISTE_Standards-T_PDF.pdf.

Jang, S. J., & Tsai, M.-F. (2012). Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards. *Computers & Education, 59*(2), 327–338. http://dx.doi.org/10.1016/j.compedu.2012.02.003.

Joreskog, K. G., & Goldberger, A. S. (1975). Estimation of a model with multiple indicators and multiples causes of a single latent variable. *Journal of the American Statistical Association, 70*(351), 631–639.

Kabakci Yurdakul, I., & Coklar, A. N. (2014). Modeling preservice teachers' TPACK competencies based on ICT usage. *Journal of Computer Assisted Learning, 30*(4), 363–376. http://dx.doi.org/10.1111/jcal.12049.
Karaca, F., Can, G., & Yildirim, S. (2013). A path model for technology integration into elementary school settings in Turkey. *Computers & Education, 68*, 353–365. http://dx.doi.org/10.1016/j.compedu.2013.05.017.
Kennisnet. (2012). *ICT proficiency of teachers (ICT-bekwaamheid van leraren)*. Nederland: Kennisnet. Retrieved fromhttp://archief.kennisnet.nl/fileadmin/contentelementen/kennisnet/Ict-bekwaamheidseisen/it-competency-framework.pdf.
Kirkup, G., & Kirkwood, A. (2005). Information and communications technologies (ICT) in higher education teaching – a tale of gradualism rather than revolution. *Learning, Media and Technology, 30*(2), 185–199. http://dx.doi.org/10.1080/17439880500093810.
Kishton, J. M., & Widaman, K. F. (1994). Unidimensional versus domain representative parceling of questionnaire items: an empirical example. *Educational and Psychological Measurement, 54*(3), 757–765.
Kline, R. B. (2010). *Principles and practice of structural equation modeling* (3rd ed.). NY: Guilford Press.
Knezek, G. A., & Christensen, R. (2008). The importance of Information Technology attitudes and competencies in primary and secondary education. In J. Voogt, & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 321–331). NewYork: Springer.
Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? the development of technological pedagogical content knowledge. *Journal of Educational Computing Research, 32*(2), 131–152.
Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2010). Examining the technological pedagogical content knowledge of Singapore pre-service teachers with a large-scale survey. *Journal of Computer Assisted Learning, 26*(6), 563–573. http://dx.doi.org/10.1111/j.1365-2729.2010.00372.x.
Kopcha, T. J., Ottenbreit-Leftwich, A., Jung, J., & Baser, D. (2014). Examining the TPACK framework through the convergent and discriminant validity of two measures. *Computers & Education, 78*, 87–96.
Krumsvik, R. J. (2011). Digital competence in the Norwegian teacher education and schools. *Högre utbildning, 1*(1), 39–51.
Krumsvik, R. J. (2014). Teacher educators' digital competence. *Scandinavian Journal of Educational Research, 58*(3), 269–280. http://dx.doi.org/10.1080/00313831.2012.726273.
Law, N. (2009). Mathematics and science teachers' pedagogical orientations and their use of ICT in teaching. *Education and Information Technologies, 14*(4), 309–323. http://dx.doi.org/10.1007/s10639-009-9094-z.
Law, N., & Chow, A. (2008). Teachers characteristics, constextual factors, and how these affect the pedagogical use of ICT. In N. Law, W. Pelgrum, & T. Plomp (Eds.), *Pedagogy and ICT use in schools around the World. Findings from the IEA SITES 2006 Study* (pp. 181–219). New York: Springer.
Markauskaite, L. (2007). Exploring structure of trainee teachers' ICT literacy: the main components of, and relationships between, general cognitive and technical capabilities. *Educational Technology Research and Development, 55*(6), 547–572. http://dx.doi.org/10.1007/s11423-007-9043-8.
McMillan, J. H., & Schumacher, S. (2010). *Research in education: Evidence-based inquiry* (7th ed.). Boston: Pearson.
Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: a new framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.
Mooij, T., & Smeets, E. (2001). Modelling and supporting ICT implementation in secondary schools. *Computers & Education, 36*(3), 265–281. http://dx.doi.org/10.1016/S0360-1315(00)00068-3.
Mueller, R. O., & Hancock, G. R. (2010). Structural equation modeling. In G. R. Hancock, & R. O. Mueller (Eds.), *The reviewer's guide to quantitative methods in the social sciences* (pp. 371–383). London: Routledge.
Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: a review of the literature. *Journal of Information Technology for Teacher Education,, 9*(3), 319–341.
Muthén, B. (1989). Latent variable modeling in heterogeneous populations. *Psychometrika, 54*(4), 557–585.
North Caroline Department of Public Instruction. (2000). *Basic technology competencies for educators*. Retrieved fromhttp://www.dpi.state.nc.us/tap/tapetsi.htm.
Office of Educational Technology. (2010). *Transforming American Education: Learning powered by technology*. Washington, D.C.: U.S. Department of Education, Office of Educational Technology. Retrieved fromhttp://www.ed.gov/sites/default/files/netp2010.pdf.
Okojie, M. C., Olinzock, A. A., & Okojie-Boulder, T. C. (2006). The pedagogy of technology integration. *Journal of Technology Studies, 32*(2), 66–71.
Orellana, N., Almerich, G., Suárez-Rodríguez, J. M., & Belloch, C. (2013). Usos y competencias en TIC del profesorado universitario. Aproximación a la modelización. In J. Gacel-Avila, & N. Orellana (Eds.), *Educación superior, gestión, innovación e internalización* (pp. 241–271). Valencia: PUV (Publicacions de la Universitat de València).
Ottestad, G., Kelentrić, M., & Guðmundsdóttir, G. B. (2014). Professional digital competence in teacher education. *Nordic Journal of Digital Literacy, 9*(4), 243–249.
Papanastasiou, E. C., & Angeli, C. (2008). Evaluating the use of ICT in education: psychometric properties of the survey of factors affecting teachers teaching with technology (SFA-T3). *Educational Technology & Society, 11*(1), 69–86.
Pelgrum, W. J. (2009a). *Indicators on ICT in primary and secondary education*. Brussels: Education, Audiovisual and Culture Executive Agency. Retrieved fromhttp://eacea.ec.europa.eu/llp/studies/documents/study_on_indicators_on_ict_education/final_report_eacea_2007_17.pdf.
Pelgrum, W. J. (2009b). Monitoring in education: an overview. In F. Scheuermann, & F. Pedró (Eds.), *Assessing the effects of ICT in education: Indicators, criteria and benchmarks for international comparisons* (pp. 41–59). Paris: European Union/OECD.
Pelgrum, W. J., & Law, N. (2003). *ICT in education around the world: Trends, problems and prospects*. Paris: UNESCO-IIEP.
Posey, C., Roberts, T. L., Lowry, P. B., & Bennett, R. J. (2014). Multiple indicators and multiple causes (MIMIC) models as a mixed-modeling technique: a tutorial and an annotated example. *Communications of the Association for Information Systems, 36*. Article 11. Retrieved from http://aisel.aisnet.org/cgi/viewcontent.cgi?article=3838&context=cais.
Ramboll Management. (2006). *E-Learning Nordic 2006: Impact of ICT on education*. Denmark: Ramboll Management. Retrieved fromhttp://www.oph.fi/download/47637_eLearning_Nordic_English.pdf.
Ritzhaupt, A. D., Dawson, K., & Cavanaugh, C. (2012). An investigation of factors influencing student use of technology in K-12 classrooms using path analysis. *Journal of Educational Computing Research, 46*(3), 229–254. http://dx.doi.org/10.2190/EC.46.3.b.
Rushton, J. P., Brainerd, J. C., & Pressley, M. (1983). Behavioral development and construct validity: the principle of aggregation. *Psychological Bulletin, 94*(1), 18–38.
Russell, G., Finger, G., & Russell, N. (2000). Information technology skills of Australian Teachers: implications for teacher education. *Journal of Information Technology for Teacher Education, 9*(2), 149–166.
Sandholtz, J., & Reilly, B. (2004). Teachers, not technicians: rethinking technical expectations for teachers. *The Teachers College Record, 106*(3), 487–512.
Schau, C., Stevens, J., Dauphinee, T., & Vecchio, A. D. (1995). The development and validation of the survey of attitudes toward statistics. *Educational and Psychological Measurement, 55*(5), 868–875.
Schumacker, R. E., & Lomax, R. G. (2010). *A beginner's guide to structural equation modeling* (3rd ed.). New York: Routledge.
Shinas, V. H., Yilmaz-Ozden, S., Mouza, C., Karchmer-Klein, R., & Glutting, J. J. (2013). Examining domains of technological pedagogical content knowledge using factor analysis. *Journal of Research on Technology in Education, 45*(4), 339–360. http://dx.doi.org/10.1080/15391523.2013.10782609.
Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.
Shulman, L. S. (1987). Knowledge and teaching: foundations of the new reform. *Harvard Educational Review, 57*, 1–22.
Sipilä, K. (2014). Educational use of information and communications technology: teachers' perspective. *Technology, Pedagogy and Education, 23*(2), 225–241. http://dx.doi.org/10.1080/1475939X.2013.813407.
Stensaker, B., Maassen, P., Borgan, M., Oftebro, M., & Karseth, B. (2007). Use, updating and integration of ICT in higher education: linking purpose, people and pedagogy. *Higher Education, 54*(3), 417–433. http://dx.doi.org/10.1007/s10734-006-9004-x.
Suárez, J., Almerich, G., Gargallo, B., & Aliaga, F. M. (2010). Las competencias en TIC del profesorado y su relación con el uso de los recursos tecnológicos. *Education Policy Analysis Archives, 18*(10). Retrieved from http://epaa.asu.edu/ojs/article/view/755/832.

Suárez-Rodríguez, J. M., Almerich, G., Díaz-García, I., & Fernández-Piqueras, R. (2012). Competencias del profesorado en las TIC. Influencia de factores personales y contextuales. *Universitas Psychologica, 11*(1), 293–309.
Suárez-Rodríguez, J., Almerich, G., Gargallo, B., & Aliaga, F. M. (2013). Las competencias del profesorado en TIC: Estructura básica. *Educación XX1, 16*(1), 39–62. http://dx.doi.org/10.5944/educxx1.16.1.716.
Tejedor, F. J., & García-Valcárcel, A. (2006). Competencias de los profesores para el uso de las TIC en la enseñanza. Análisis de sus conocimientos y actitudes. *Revista Española de Pedagogía, 223*, 21–44.
Teo, T., Milutinović, V., & Zhou, M. (2016). Modelling Serbian pre-service teachers' attitudes towards computer use: a SEM and MIMIC approach. *Computers & Education, 94*, 77–88. http://dx.doi.org/10.1016/j.compedu.2015.10.022.
Tezci, E. (2010). Attitudes and knowledge level of teachers in ICT use: the case of Turkish teachers. *International Journal of Human Sciences, 7*(2), 19–44. Retrieved fromhttp://www.j-humansciences.com/ojs/index.php/IJHS/article/view/797.
Thompson, M. S., & Green, S. B. (2006). Evaluating between-group differences in latent variable means. In G. Hancok, & R. Mueller (Eds.), *Structural equation modeling. A second course* (pp. 119–169). Greenwich, Conn.: Information Age Publishing.
Tondeur, J., Aesaert, K., Pynoo, B., van Braak, J., Fraeyman, N., & Erstad, O. (2015). Developing a validated instrument to measure preservice teachers' ICT competencies: meeting the demands of the 21st century. *British Journal of Educational Technology*. http://dx.doi.org/10.1111/bjet.12380. In press.
Tondeur, J., Valcke, M., & van Braak, J. (2008). A multidimensional approach to determinants of computer use in primary education: teacher and school characteristics. *Journal of Computer Assisted Learning, 24*, 494–506. http://dx.doi.org/10.1111/j.1365-2729.2008.00285.x.
UNESCO. (2002). *Information and communication technologies in teacher education: A planning guide*. Paris: UNESCO.
UNESCO. (2008). *ICT competency standards for teachers*. London: UNESCO. Retrieved fromhttp://unesdoc.unesco.org/images/0015/001562/156207e.pdf.
UNESCO. (2011). *UNESCO ICT competency framework for teachers*. Paris: UNESCO. Retrieved fromhttp://iite.unesco.org/pics/publications/en/files/3214694.pdf.
Vanderlinde, R., Aesaert, K., & van Braak, J. (2014). Institutionalised ICT use in primary education: a multilevel analysis. *Computers & Education, 72*, 1–10. http://dx.doi.org/10.1016/j.compedu.2013.10.007.
Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to learning and schooling in the digital networked world of the 21st century. *Journal of ComputerAssisted Learning, 29*(5), 403–413. http://dx.doi.org/10.1111/jcal.12029.
Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge–a review of the literature. *Journal of Computer Assisted Learning, 29*(2), 109–121. http://dx.doi.org/10.1111/j.1365-2729.2012.00487.x.
Voogt, J., Knezek, G., Cox, M., Knezek, D., & ten Brummelhuis, A. (2013). Under which conditions does ICT have a positive effect on teaching and learning? A Call to Action. *Journal of Computer Assisted Learning, 29*(1), 4–14. http://dx.doi.org/10.1111/j.1365-2729.2011.00453.x.
Wang, W. C., & Shih, C. L. (2010). MIMIC methods for assessing differential item functioning in polytomous items. *Applied Psychological Measurement, 34*(3), 166–180. http://dx.doi.org/10.1177/0146621609355279.
Wastiau, P., Blamire, R., Kearney, C., Quittre, V., Van de Gaer, E., & Monseur, C. (2013). The use of ICT in education: a survey of schools in Europe. *European Journal of Education, 48*, 11–27. http://dx.doi.org/10.1111/ejed.12020.
Whitworth, A. (2012). Invisible success: problems with the grand technological innovation in higher education. *Computers & Education, 59*(1), 145–155. http://dx.doi.org/10.1016/j.compedu.2011.09.023.