University students’ competences in ICT: A view from the education domain

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Contemporary university students face the knowledge society, where mastering information and communication technologies (ICT) is an essential requirement to form part of this society. The objective of our study was to validate a basic ICT competences model made up of three ICT competence subsets (technological, pedagogical and ethical) influenced by various personal and contextual factors. For this purpose, a cross-sectional explanatory correlation design was used, with a sample of 646 university students from the University of Valencia (Spain), collecting the information through a questionnaire. A multiple indicators and multiple causes model was used to validate the students’ ICT competences model. The results revealed that ICT competences form a single set made up of three subsets of competences: technological, pedagogical and ethical. An asymmetrical explanatory relation was found between the technological and pedagogical competences on the one hand and between the ethical and pedagogical competences on the other hand. The factors gender, area in which the degree is taught and the frequency of using a computer with the Internet impacted on the three subsets of competences. The model shows the complexity of university students’ ICT competences, with training in ICT competences being an important element to consider.

Implications for practice or policy:

- University leaders have to include the three ICT competence subsets in the curriculum.
- University teachers must promote the three ICT competence subsets in their classes.
- Instructional designers and educational technologists should include the three ICT competences subsets in their training plans.

Keywords: ICT competences, students, university, model of competences, personal factors, contextual factors

Introduction

Today’s society is characterised by constant changes in technology, which impact on education, labour, entertainment and communication (Huffman & Huffman, 2012). Therefore, educational institutions must prepare professionals who can adapt to working in an ever-changing and constantly developing environment (Bakhshi et al., 2017).

University is no exception to these changes. Indeed, European higher education has attempted to not only orientate university education to specific training but also to go even further to develop more general competences, such as competences in information and communication technologies (ICT) (European Commission, 2017, 2018). Hence, mastering ICT competences is now an objective in university student training to allow students to fully engage in the knowledge society (European Commission, 2017; Siddiq et al., 2016). Students have to be able to acquire the knowledge and skills they need to properly use ICT so that they can manage and communicate information (European Commision, 2018; Red de Bibliotecas Universitarias, 2016).

ICT competences focus not only on the technical aspects of technological resources (Spante et al., 2018) but also on the orientation to cognitive perspectives (Spante et al., 2018). Thus, university students are expected to be capable of transforming information into knowledge because it is no longer enough to merely have access to and evaluate information (Alexander et al., 2019). Hence, ICT competences require that university students be creators (Alexander et al., 2016) by favouring critical thinking and complex problem-solving through mastering technological resources (Alexander et al., 2019). Likewise, it is also necessary to consider mastering ICT and creating knowledge from an ethics perspective, as well as digital citizenship (Alexander et al., 2016).

Therefore, for university students, ICT competences represent mastering the different technological resources that allow them to manage information to create knowledge and to communicate it, and all this is encompassed from an ethical perspective. In addition, in ICT competences, the socio-cultural environment surrounding university students must be taken into account (Alexander et al., 2016). For this reason, it is necessary to establish the basic structure of university students' ICT competences, by considering how students' personal and contextual factors affect it. Accordingly, the present research work answers to this purpose.

The ICT competence framework for students

ICT competences have generally been termed in many ways, for example, digital competence, digital literacy, computer skills (Siddiq et al., 2016; van Braak, 2004). When we focus on students, we contemplate ICT competences as a set of knowledge and skills that students must acquire in several technological resources that they can use to do different academic tasks and/or training activities in a way that is safe and ethically responsible.

In recent decades, different national and/or international organisations, along with several authors, have established ICT competence frameworks for students. A first set of proposals stems from frameworks that address the general population, such as the ICDL Digital citizen (International Computer Digital Literacy Europe, 2023) and the European digital competence framework for citizens (Vuorikari et al., 2016). The second set of proposals includes competence frameworks for students in education systems like those provided by the International Society for Technology in Education (ISTE, 2016) and the International Association for the Evaluation of Educational Achievement (IEA; Fraillon et al., 2019). One proposal from Spain centres more on university student training and is offered by the University Libraries Network (Red de Bibliotecas Universitarias, 2016) with its digital competence framework for degree students. The third group of ICT competence frameworks is provided by different authors such as Calvani et al. (2010) for secondary education students and van Braak (2004), Arras et al. (2011) and Verhoeven et al. (2016) for university students.

One of the problems of these competence frameworks is that because of the diversity of the competences no explicit clear structuring exists as to which type of ICT competences students should acquire. Thus, we distinguish three subsets of competences: technological, pedagogical and ethical. In addition, from our point of view, ethical competence forms its own subset, which other authors (Arras et al., 2011; Calvani et al., 2010; Díaz-Garcia et al., 2016; Kabakci Yurdakul & Coklar, 2014; Torres-Gastelú & Kiss, 2016) and organisations (ISTE, 2016) have also suggested. In this way, we organise ICT competences into the following three subsets:

- Technological competences are understood as a set of knowledge and skills that students acquire from technological resources, which enable students to properly use them.
- Pedagogical competences are considered as a set of knowledge and skills that allow technological resources to carry out the academic tasks and/or training activities to be integrated by students.
- Ethical competences refer to a set of knowledge and skills that relate to the global, legal and ethical use involved in technological resources, and also to their use and authorship being acknowledged and/or the training activities performed by students.

An ICT competences model for university students: basic structure

This section presents an ICT competences model for university students in accordance with the three subsets of competences, along with personal and contextual factors.

Different studies have been carried out on ICT competences in university students over the years (Arras et al., 2011; Cabezas-González et al., 2016; Castaño et al., 2012; McCoy, 2010; Nami & Vaezi, 2018;

Torres-Gastelú & Kiss, 2016; van Braak, 2004; Verhoeven et al., 2016). One characteristic of these studies is that they have centred on evaluating students' level of competences by separately analysing each subset of competences: technological, pedagogical and ethical. They have focused especially on technological competences. This suggests a limitation for the ICT competences model because no relation has been established among the three subsets of competences and the way they are structured has not been investigated. So, studies that examine the interrelation of these three subsets are necessary.

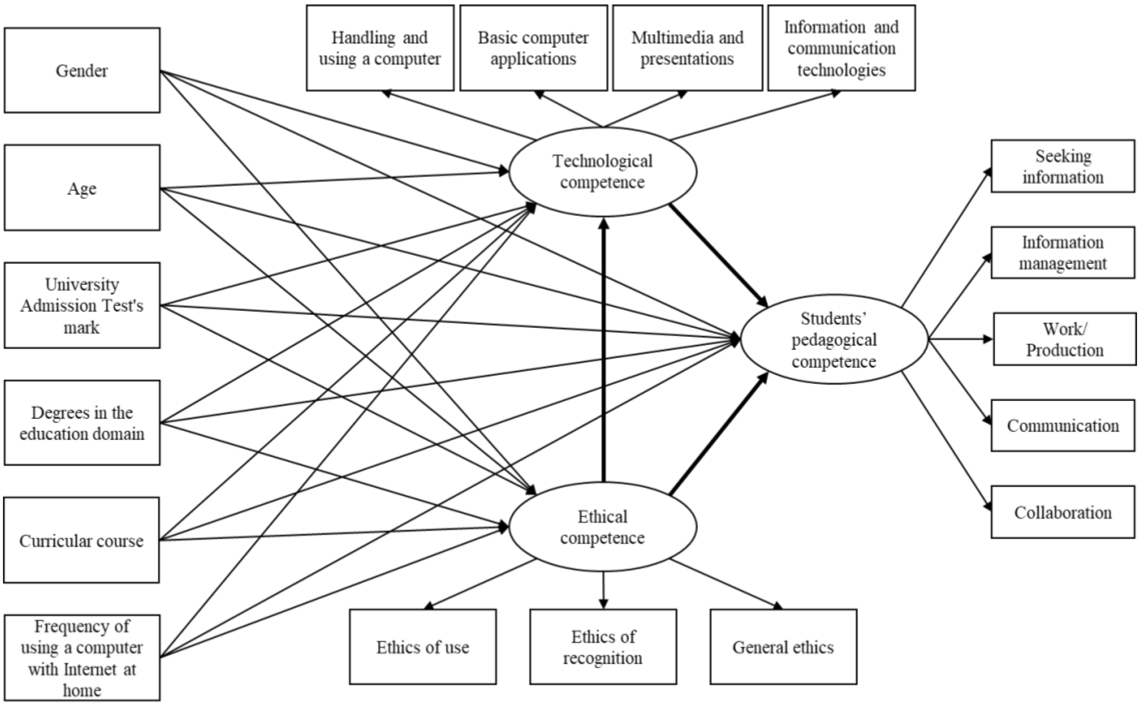


Figure 1. Model of university students' ICT competences, along with personal and contextual factors

Our ICT competences model for university students (see Figure 1) is made up of the three subsets of competences: technological, pedagogical and ethical. In turn, all three subsets of competences are made up of components (see Figures 1, 2, 3 and 4) that correspond to the indicators of the three subsets of competences or latent variables. Moreover, different personal and contextual factors are considered in the model.

The proposed model establishes different relationships between the three subsets of competences (see Figure 1). Firstly, technological competences influence pedagogical competences (see Figure 1). Krumsvik (2011) indicated that technological competences are the first of the four components forming his proposed model for teachers and student teachers. Mooij and Smeets (2001) indicated that a lack of technological competence is an obstacle for teachers to use them in class. In empirical terms, Suárez-Rodríguez et al. (2013) and Almerich et al. (2016) found that technological competences influenced pedagogical competences with teachers. From the students' point of view, Hatlevick et al. (2015) found that self-efficacy with ICT is a predictor of digital competences with upper secondary education students. Consequently, it is reasonable to establish that technological competences are a predictor of pedagogical ones in university students.

Secondly, ethical competences influence both technological and pedagogical competences. Ethical competences, also known as digital citizenship (Alexander et al., 2016; Law et al., 2018), have increased within ICT competence frameworks, but the scope of their definition is subject to problems (Law et al., 2018). This problem has been transferred to studies about ICT competences because very few studies have included ethical competences as a subset of competences (Arras et al., 2011; Calvani et al., 2010; Díaz-García et al., 2016; Kabakci Yurdakul & Coklar, 2014; Torres-Gastelú & Kiss, 2016), and even fewer studies have investigated the relation of ethical competences in ICT to other subsets of competences;

readers are referred to the study on student teachers by Kabakci Yurdakul and Coklar (2014), who found a positive and significant correlation between the ethical factor and the other three competence factors relating to ICT in their model (design, effort and competence). Therefore, ethical competences form an essential subset that is related to the other subsets of ICT competences. The ISTE's (2016) Digital Citizenship standard for students points out the need to act safely, legally and ethically in the digital world by always behaving ethically when using technology. The European Commission (2018) states that people must be aware of the legal and ethical principles that using ICT entails and make ethical, safe and responsible considerations when employing these tools. Alexander et al. (2016) have pointed out that a part of ICT competences involves understanding why a technological resource is useful in the real world and how it is properly used: digital citizenship. From these three perspectives, the ethical component of ICT competences forms part of them and also impacts the other subsets of competences and their use. As suggested by Krumsvik (2011), according to their model, both teachers and students have to develop ethical competences with which they acquire a meta perspective about other student teachers' digital competence components. Consequently, the ethical competences in our model suggest learning and awareness, which are the basis of the other two subsets of competences: technological and pedagogical.

Thirdly, the three competences model components are influenced by different personal and contextual factors, given the importance of the socio-cultural environments surrounding students, as previously mentioned. One of the key aspects needed to understand the integration of ICT lies in the fact that it is a complex dynamic process (Knezek & Christensen, 2016) in which different factors come into play (Lim et al., 2013; McCoy, 2010; Verhoeven et al., 2016). Basically, and to further the proposal of Ertmer (1999), from teachers to students, it is possible to distinguish between the contextual factors surrounding students, or first-order factors, and students' own personal factors, or second-order factors. The following personal factors have been covered in research works: gender (Arras et al., 2011; Cabezas-González et al., 2016; Castaño et al. 2012; Nami & Vaezi, 2018; Tien & Fu, 2008; van Braak, 2004; Verhoeven et al., 2016; Yalman et al., 2016), age (Cabezas-González et al., 2016; Castaño et al. 2012, McCoy, 2010), frequency of using a computer or the Internet (Baturay et al., 2017; Castaño et al. 2012; McCoy, 2010; Nami & Vaezi, 2018; van Braak, 2004; Yalman et al., 2016) and students' marks (Tien & Fu, 2008; De Wit et al., 2012). For the contextual factors, studies have considered curricular course (Kaminski et al., 2009) and the degree being studied (Castaño et al. 2012; Nami & Vaezi, 2018; Tien & Fu, 2008; Verhoeven et al., 2016). Differences are found for all the factors in the different subsets of competences.

Purpose of this study

The general objective of the present work was to build a basic ICT competences model for university students – one that corresponds to degrees in the education domain. We considered technological, pedagogical and ethical competences, along with a series of personal and contextual factors which, together, establish the relational structure of the whole set. We considered all of this from multivariate positions as different interlinked factors exist, which other authors have suggested (Aesaert et al., 2015; Almerich et al., 2016; Law & Chow, 2008). This general objective is expressed in three specific objectives:

- validate a basic ICT competences model for university students in the education domain
- establish the interrelation that links the three subsets of ICT competences
- determine the influence of personal and contextual factors on the structure of these competences.

Method

Design

The present study is cross-sectional as the questionnaire was handed out only once. It is also explanatory because it involved testing a theoretical model that derives from an underlying theory in which a set of variables that play different roles is asymmetrically related (Ato et al., 2013). In particular, it is a correlational study design (McMillan & Schumacher, 2010) based on a survey study.

Participants

The sample consisted of 646 university students studying degrees in pedagogy, psychopedagogy, social education, teacher training, speech therapy, science of physical activity and sport, and a master's degree in secondary education teaching, in different Universidad de Valencia faculties. The sample distribution according to the key personal and contextual variables is found in Table 1.

The sample was formed by non-probabilistic intentional sampling. Two criteria were considered for the selection of the participants. The first criterion was that the students belonged to the education domain, since they are future teaching professionals. The second criterion was to find variety in the participants; therefore, teachers in training were taken into account together with students who could later be involved in teaching. In order to access the participants, we contacted their teachers and explained the research purpose, and they agreed that the protocol be administered to the students in their class.

Table 1
The sample's characteristics

Gender	Males: 27.6%; Females: 72.4%
Age	Mean = 24.3 years; range: 19–56
Area where the degree in education based on its relationship with the education domain	- Degrees in education (teacher training – 13.3%; pedagogy – 13%; social education – 13%): 39.3% - Degrees more related to education (psychopedagogy – 25.1%; Master in Secondary Education Teaching – 15.9%): 41% - Degrees less related to education (science of physical activity and sport –13.8%; speech therapy – 5.9%): 19.7%
Curricular course	Undergraduate studies: 1st year: 32.8% 2nd year: 22.3% 3rd year: 3.3% 4th year: 17.3% Master: 15.9%
Frequency of using a computer with the Internet at home	Never or almost never: 2.5% Sometimes: 4.6% Almost always: 23.5% Always: 69.3%

Instruments

The data collection instrument was a questionnaire designed especially for this purpose, which belongs to a much broader protocol (students' characteristics; access to computer equipment; ICT competences (technological, pedagogical and ethical); ICT use (personal and academic); integrating ICT; and attitudes to ICT) is based on the work of Suárez-Rodríguez et al. (2010). We designed an instrument that takes into account the three competence subsets and their components that constitute ICT competences, since the studies reviewed did not consider them as a whole.

This work centres on the following protocol sections: students' characteristics, access to computer equipment, ICT knowledge and skills (in technological, pedagogical and ethical competences).

The ICT competences questionnaire is made up of three scales, together with their components, representing the three subsets that make up the set of ICT competences of university students. These three scales are as follows:

- The technological competences section consists of 44 items (see Figure 2). These items are included in four basic components: handling and using a computer; ICT; basic computer applications; and presentations and multimedia applications. The items in each component are progressively arranged and indicate the students' knowledge and skills about certain operations.

In this way, the first items of each component correspond to the most basic knowledge, while the last ones correspond to advanced knowledge about technological tools. The 5-point Likert-type scale ranges from *nothing* to *a lot*. The reliability of the whole scale is α = .95.

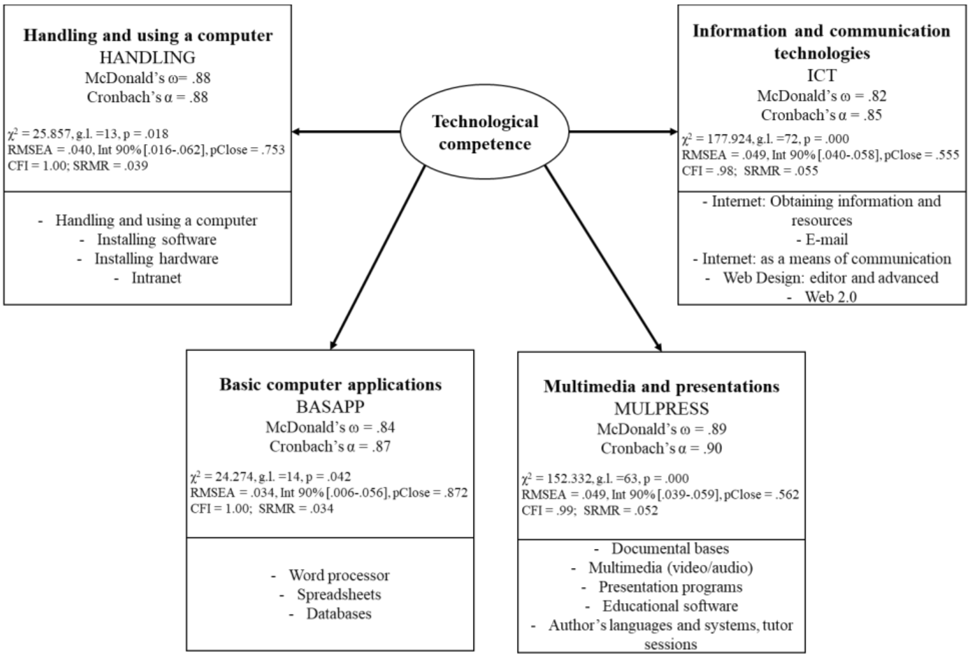


Figure 2. Basic components of technological competence

- The pedagogical competences section contains 32 items (see Figure 3). This asks students how they integrate ICT into their academic tasks and/or training activities. This section includes items on five components: seeking information; collaboration; work/production; communication with the teacher and classmates; and information management. Items are progressively arranged so that the first ones on each component represent lower competence levels than the last ones on each component. The 5-point Likert-type scale ranges from *never* to *always*. The scale's total reliability is α = .93

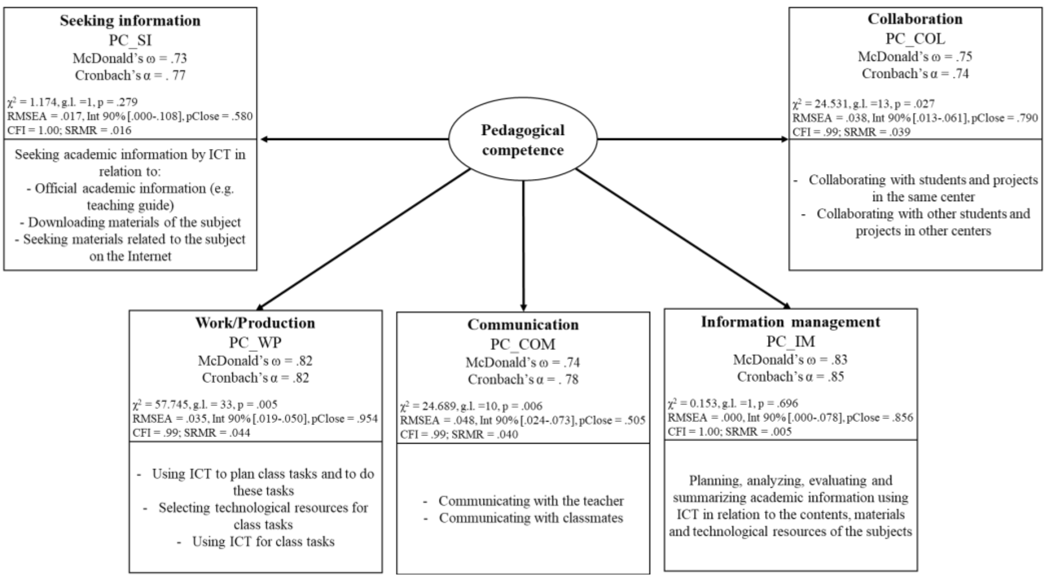


Figure 3. Basic components of pedagogical competence

- The ethical competences section (see Figure 4) comprises five items on three components: ethics of use, ethics of recognition and general ethics. Here, students were asked about the ethical aspects related to legally using technological materials and resources and recognising authorship in their academic tasks and/or training actions. The 5-point Likert scale ranges from *never* to *always*. The scale's total reliability is α = .81

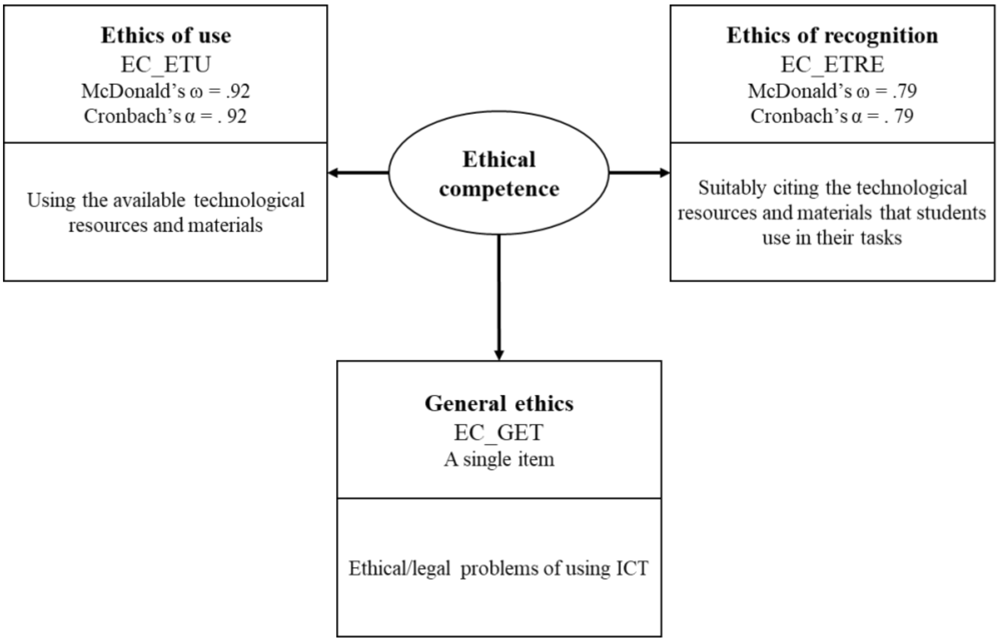


Figure 4. Basic components of ethical competence

Data analysis

The data analyses were descriptive and statistical and obtained by SPSS version 24.0 software. Modelling was done by structural equations with the LISREL 8.8 programme.

To validate the model, a multiple indicators and multiple causes model (MIMIC) was used (Jöreskog & Goldberger, 1975). MIMIC allows the complexity of the situation to be dealt with, particularly when there are several covariate variables, which suggests there may be a mixture of measures, from nominal to continuous, which influence the structural model's variables. MIMIC also suggests a smaller sample size than the multi-sample analysis (Kline, 2010).

The model's estimations were made following the robust maximum likelihood method given the non-normality of the components employed (see Table 2). To evaluate the model's fit, adjusted χ^2, following the Satorra-Bentler procedure, was conducted. Some authors (e.g., Byrne, 2012; Kline, 2010) have recommended using other indicators to evaluate fit, along with acceptance thresholds. In our case, and according to Byrne (2012) and Kline (2010), we chose root mean square error of approximation (RMSEA) and considered a good fit when a value equalled or was below .05, along with its 90% confidence interval and its probability; the comparative fit index (CFI), where good fit values are considered to equal or be above .95; the standardised root mean square residual (SRMR), with values that equal or are below .05. They all indicate the model's good fit.

In order to arrange the indicators of the three subsets of competences according to the components, a decision was made to form parcels of items. According to Nasser and Wisenbaker (2003), a parcel is used to refer to an indicator or observed variable, which is the mean of several items that evaluate a unidimensional construct. The parcel is preferred in structural equation models and for confirmatory factor analyses (CFA) because, given that "parcels reduce the number of indicators involved in modeling, researchers are able to use more realistic models that better capture increasingly complex theories of human behavior" (Naser & Wisenbaker, 2003, p. 730). This was the selected option given the characteristics of this situation as the scale on which items were measured (a 5-point Likert scale in all three cases), and the existence of clear *difficulty* associations between items (items went from more basic competence levels to more advanced ones in each subset of competences), constitute distinct asymmetrical distributions that suggest problems in the factor analysis (Gorsuch, 1997; Nunnally & Berstein, 1994) and gave a complex structure that did not clearly and easily structure this field. Thus, parcelling items in this situation is recommended (West et al., 1995; Yang et al., 2010). For the unidimensionality requirement of parcels (Nasser & Wisenbaker, 2003), a CFA was run for each parcel of technological and pedagogical competences by the diagonally weighted least squares estimation method given the metrics and descriptives of items (Finney & DiStefano, 2013). This allowed us to verify that all the dimensions of both subsets of competences presented unidimensionality because fit indices were adequate (see Figures 2 and 3). With ethical competences, and for the number of items per dimension, unidimensionality was checked by an exploratory factor analysis (EFA) following the main axis estimation method. The unidimensionality of dimensions was also checked (see Figure 4). Cronbach's α was presented on each dimension, and McDonald's ω was calculated with the CFA and the EFA (see Figures 2, 3 and 4), where all the dimensions showed appropriate reliability indices.

Finally, checks were made of the ordered dimensions' structure to determine if they suitably reflected the three subsets of competences. To do so, an EFA was run using the main axis estimation method and promax rotation. As Figure 5 illustrates, both the Kayser-Meyer-Olkin index and Bartlett's test of sphericity indicate the suitability of the factor analysis. Three factors were extracted with suitable loadings in each one; these adequately represented the theoretical structure of the three subsets of competences (technological, pedagogical and ethical).

Procedure

The questionnaire data were collected using printouts, which the participating teacher took to class and asked the students to complete. The research took into account all the guidelines required by the Ethics Committee of the Universidad de Valencia to conduct such research. Students were informed of the study objective and the importance of responding to it. The confidentiality of their responses and the anonymity of their data were guaranteed both verbally and in writing.

Students' participation in the study was voluntary, and they were offered no incentive for participation.

KMO Test

Kaiser-Meyer-Olkin Measure of sampling adequacy	.871

Bartlett's test

Bartlett's Test of Sphericity	Approx. Chi-Square	3683.050
	df	66
	Sig.	.000

Total variance explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.910	40.913	40.913	4.531	37.755	37.755
2	2.138	17.818	58.730	1.684	14.035	51.789
3	1.071	8.925	67.655	.647	5.395	57.185
4	.780	6.497	74.153			
5	.616	5.133	79.286			
6	.478	3.981	83.267			
7	.444	3.699	86.966			
8	.423	3.525	90.491			
9	.354	2.946	93.437			
10	.305	2.540	95.977			
11	.254	2.119	98.095			
12	.229	1.905	100.000			

Pattern matrix

	Factor		
	1	2	3
Handling and using a computer		.915	
Basic computer applications		.719	
Multimedia and presentations		.806	
Information and communication technologies		.707	
Seeking information	.629		
Work/Production	.860		
Communication	.736		
Information management	.879		
Collaboration	.558		
General ethics			.749
Ethics of use			.552
Ethics of recognition			.682

No loadings below .30 are shown

Figure 5. EFA of the components of three subsets of competences

Results

Descriptive analysis of the university students' ICT competences

The level of the students' ICT competences is generally limited, as Table 2 shows, and their level of pedagogical competences was the highest.

Table 2
Descriptive statistics of the university students' competences

	Components	Mean	SD	Form of distribution: Skewness	Form of distribution: Kurtosis	Normality test with skewness and kurtosis: χ^2	Normality test with skewness and kurtosis: Sig.
Technological Competences	Handling and using a computer	3.40	0.900	-0.107	-0.660	28.077	0.000
	Basic computer applications	3.26	0.804	0.034	-0.382	5.853	0.054
	Multimedia and presentations	2.93	0.755	-0.015	-0.234	1.721	0.423
	Information and communication technologies	3.09	0.637	-0.041	0.192	1.218	0.544
Pedagogical competences	Seeking information	4.06	0.730	-0.662	-0.079	40.483	0.000
	Work/production	3.31	0.703	-0.126	-0.342	6.059	0.048
	Communication	3.12	0.761	0.081	-0.323	4.473	0.107
	Information management	3.50	0.929	-0.263	-0.523	20.777	0.000
	Collaboration	2.48	0.752	0.589	-0.002	33.021	0.000
Ethical competences	General ethics	2.89	1.228	0.052	-0.887	77.901	0.000
	Ethics of use	3.22	1.143	-0.178	-0.631	26.758	0.000
	Ethics of recognition	3.16	1.084	-0.040	-0.774	46.238	0.000

The students' level of technological competences was that of normal users handling a computer, basic computer applications and ICT. On the multimedia and presentations component, their level of competences was lower than for the rest, which suggests a level with limitations and gaps for several resources.

The level at which students had integrated pedagogical competences, and how they used ICT in their academic tasks and/or training activities, was regular. The seeking information component was where they obtained higher scores, which almost always referred to access to teaching guides, notes and the material of subjects collected in virtual classes and on websites. Notably, the students barely used ICT to undertake tasks with the tools offered on the Internet for collaborative work.

Regarding ethical competences, students sometimes considered technological resources and software, but not the fact that they are legally available in their training tasks. They barely recognised the ethical and legal problems that result from using technological resources.

The correlations (see Table 3) revealed that the intensity of the relation was much stronger among the components integrating all the subsets of competences than for the other subsets components. In gender terms, males were more linked with technological competences, while females were more linked with pedagogical and ethical ones. Age was negatively related essentially to technological competences. The university admission test's mark was poorly connected with the three competence areas, but a negative relation with ethical competences stood out. According to the area in which the degree was taught, a slightly negative link was observed with technological competences. Curricular course was related positively to some components of technological and pedagogical competences, and negatively with ethical competences. Finally, the frequency of using a computer with Internet at home was positively related to technological and pedagogical competences, but was not related to ethical ones.

Table 3

The correlation matrix between the competence components and the personal and contextual factors

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Handling and using a computer	1.00																	
2. Basic computer applications	0.65**	1.00																
3. Multimedia and presentations	0.66**	0.62**	1.00															
4. Information and communication technologies	0.66**	0.58**	0.73**	1.00														
5. Seeking information	0.31**	0.32**	0.35**	0.37**	1.00													
6. Work/Production	0.35**	0.43**	0.47**	0.48**	0.61**	1.00												
7. Communication	0.28**	0.37**	0.42**	0.47**	0.47**	0.59**	1.00											
8. Information management	0.30**	0.37**	0.39**	0.42**	0.60**	0.76**	0.56**	1.00										
9. Collaboration	0.20**	0.26**	0.38**	0.41**	0.30**	0.52**	0.56**	0.47**	1.00									
10. General ethics	0.02	0.06	0.09**	0.06	0.18**	0.28**	0.17**	0.28**	0.20**	1.00								
11. Ethics of use	-0.18**	-0.13**	-0.13**	-0.11**	0.06	0.12**	0.03	0.08*	0.07	0.40**	1.00							
12. Ethics of recognition	0.07	0.12**	0.16**	0.10*	0.27**	0.34**	0.23**	0.33**	0.30**	0.53**	0.36**	1.00						
13. Gender	-0.37**	-0.20**	-0.14**	-0.14**	0.25**	0.14**	0.15**	0.17**	0.11*	0.22**	0.26**	0.21**	1.00					
14. Age	-0.10*	0.01	-0.25**	-0.22**	0.04	-0.01	-0.03	0.04	-0.09*	0.04	-0.05	0.00	-0.06	1.00				
15. University admission test's mark	0.08*	0.12**	0.08	0.05	0.14**	0.04	0.06	0.12**	0.02	-0.06	-0.13**	-0.02	-0.04	0.13**	1.00			
16. Degrees in the education domain	-0.12**	-0.09*	-0.02	-0.02	0.05	0.07	0.01	0.07	0.10*	0.10**	0.18**	0.06	0.43**	-0.11*	-0.34**	1.00		
17. Curricular course	0.14**	0.23**	-0.03	0.08*	0.14**	0.12**	0.14**	0.18**	-0.07	-0.05	-0.25**	-0.14**	-0.16**	0.53**	0.25**	-0.42**	1.00	
18. Frequency of using a computer with Internet at home	0.29**	0.19**	0.28**	0.28**	0.32**	0.27**	0.30**	0.25**	0.17**	-0.05	-0.05	0.06	0.05	-0.04	0.08*	-0.09	0.06	1.00

* The correlation is significant at 0.05 (bilateral). **The correlation is significant at 0.01 (bilateral).

Basic model of university students' ICT competences

This section presents the structure of the basic ICT competences model that the students showed, based on a structure with three latent variables (technological competences, pedagogical competences, ethical competences), each with measurements corresponding to the components listed in the above sections. This measurement structure is framed within MIMIC (see Figure 6), where the latent variables of competences are explained or modified, partly by the influence of the different personal and contextual variables: gender, age, university admission test's mark, area in which the degree is related to education, curricular course and general frequency of using a computer connected to the Internet at home.

The model clearly shows a good fit (see Table 4). Thus, $\chi 2$, adjusted by the Satorra-Bentler procedure, was not significant, which implies the model's good fit. The other considered indicators (RMSEA, CFI and SRMR) indicated the model's suitable or most suitable fit.

Table 4
The fit indicators of MIMIC

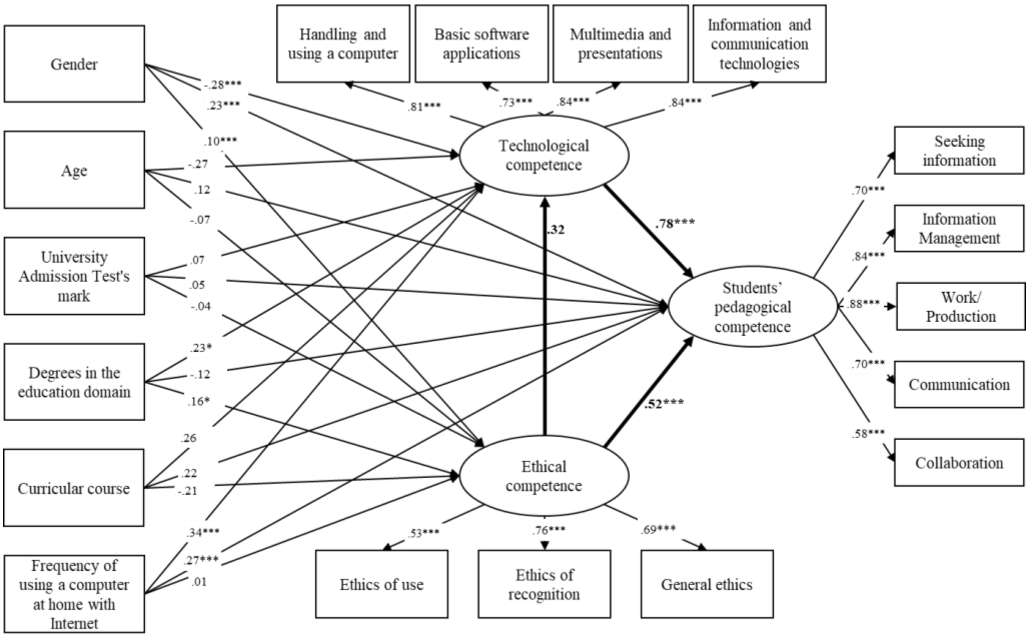
χ^2_{S-B}			RMSEA			CFI	SRMR
χ^2_{S-B}	g.l.	p	RMSEA	Int 90%	Pclose		
113.46	120	0.65	0.00	0.00-0.34	1.00	1.0	0.062

For the measurement model (see Figure 6), the three latent variables (technological, pedagogical and ethical competences) were suitably represented by the considered indicators and were clearly significant (p < .001). Nearly all the saturations were above .70, basically in the technological and pedagogical competences. The level of the ethical competences was acceptable, except for the questions about recognising the ownership of the tools and instruments, and when they are used. The reliability indices (see Table 5) equalled or were above a .70, which represents suitable internal consistency. Consequently, the measurement model proved satisfactory and adequately explained the latent variables.

Table 5
Reliability of the subsets of competences

Latent variables	Cronbach's α	McDonald's ω
Technological competences	.87	.88
Pedagogical competences	.85	.86
Ethical competences	.70	.70

The structural model indicated that technological competences significantly influenced pedagogical ones, with a value of .78. In turn, ethical competences significantly impacted both pedagogical (.52) and technological ones, albeit to a lesser extent and not significantly so (.32).



*p ≤ 0.05. **p ≤ 0.01. ***p ≤ 0.001.

Figure 6. Standardised MIMIC model

The influence of the personal and contextual factors on both types of competences (see Figure 6 and Table 6) was not relevant in all cases. Gender had a direct effect, which impacted the three competence areas and was clearly significant because the male students (coded as 0) obtained higher levels for technological competences than their female counterparts (coded as 1), while the opposite was found for pedagogical competences. Nonetheless, this influence was compensated by the indirect effect that technological competences had on pedagogical ones. Thus, the total gender effect on pedagogical competences was insignificant ($p \leq .10$). The female students presented a higher level for ethical competences in relation to ICT, where they displayed a different inclination to basic technological areas and, in turn, were measured by the competences relating to the ethical questions on them.

Table 6

Effects (direct, indirect and total) of the covaried variables on the competence components in MIMIC

	Covariates	Direct effect	Indirect effect	Total effect
Technological competences	Gender	-0.31***	0.03	-0.28***
	Age	-0.29	0.03	-0.27
	Access mark	0.08	-0.01	0.07
	Area of degree	0.26*	-0.03	0.23*
	Curricular course	0.32	-0.06	0.26
	Frequency of use	0.32***	0.02	0.34 ***
Pedagogical competences	Gender	0.17***	-0.07	0.10***
	Age	0.01	-0.08	-0.07
	Access mark	0.03	0.02	0.05
	Area of degree	0.11	0.05	0.16*
	Curricular course	0.21	0.03	0.22
	Frequency of use	0.13**	0.14***	0.27***
Ethical competences	Gender	0.23***		0.23***
	Age	0.12		0.12
	Access mark	-0.04		-0.04
	Area of degree	-0.12		-0.12
	Curricular course	-0.21		-0.21
	Frequency of use	0.01		0.01

*p ≤ 0.05. **p ≤ 0.01. ***p ≤ 0.001.

Frequency of using a computer connected to the Internet significantly affected both technological and pedagogical competences: regular use always positively affected competences in relation to ICT. The strongest influence was found for technological competences, although the combination of direct and indirect effects had a similar effect, namely a slightly weaker one, for pedagogical competences.

Finally, the area in which the degree is taught – more or less centred on education training – influenced both technological and pedagogical competences, but to a lesser extent than the variables that we previously pointed out. This influence was slightly stronger in the technological competences area, and became stronger when the degree centred more on training in the education domain.

None of the other factors had a significant impact on any of the competence components.

On the whole, this model explained 43% of technological competences, 65% of pedagogical ones and 15% of ethical ones. This means that the personal and contextual variables considered in the model, and the relations incorporated into the three competence domains, explained the ICT competences shown by university students very well.

Discussion

Firstly, the results reveal that the university students in the education area of the Universidad de Valencia have a medium level of ICT competences, a higher one for pedagogical ones, followed by technological and ethical competences. Our students consider pedagogical competence, albeit not regularly, but basically seek and manage information. Their level of technological competences is that of normal users, that is, those who master technological resources, but not advanced functions because they centre mainly on handling and using a computer with basic computer applications. Finally, their level of ethical competences is normal, and they occasionally contemplate the ethical and legal aspects that using the ICT involves for their academic and formative tasks. They also recognise authorship. These results partly coincide with other research works (Arras et al., 2011; Baturay et al., 2016; Cabezas-González et al., 2016; Nami & Vaezi, 2018; Torres-Gastelú & Kiss, 2016; Verhoeven et al., 2016), although it represents an advance with respect to them. Thus, on the one hand, this study focused on the three subsets of ICT competences (technological, pedagogical and ethical) and not only on technological competences (Baturay et al., 2016; Cabezas-González et al., 2016; Nami & Vaezi, 2018; Verhoeven et al., 2016). On the other hand, the delimitation of the dimensional makeup of the three subsets of ICT competences represents an advance that goes beyond the approach of a single component (Arras et al., 2011; Torres-Gastelú & Kiss, 2016). All this represents a broader perspective that allows a more detailed consideration of the university student's ICT competencies and their mastery.

Secondly, a structural model of university students' ICT competences was validated in the education domain, so that the three ICT competence subsets are explanatorily and asymmetrically related. The proposed measurement model was satisfactory and showed internal consistency and that the indicators of all the competence domains were appropriate, which suggests that their dimensionalisation was suitable. It also confirmed the dimensionality obtained by the EFA. The proposed structural model revealed that technological competences were the background to pedagogical ones as the former influenced the latter, which has been found in teachers (Almerich et al., 2016; Suárez-Rodríguez et al., 2013) and is similar to that reported by Hatlevick et al. (2015). Ethical competences conditioned pedagogical ones, which is the background indicated by Krumsvik (2011), the ISTE (2016) and the European Commission (2018). Conversely, no statistically significant link was found between technological and ethical competences, as proposed in the theoretical model. Finally, the fact that technological competences were more influential than ethical ones on pedagogical competences is noteworthy.

Thirdly, the considered personal and contextual factors evidenced a complex structure, which somewhat undid its univariate connections with the three competence areas. Based on the proposed structural model, gender, area where the degree was taught and frequency of using a computer with the Internet at home were relevant factors. Thus, in gender terms, males were more linked with technological competences, which falls in line with other studies (Cabezas-González et al., 2016; Castaño et al. 2012; Tien & Fu, 2008; Verhoeven et al., 2016). Nonetheless, Baturay et al. (2016) and Nami and Vaezi (2018) observed no gender differences for technological competences in multivariate terms. Female students were related more to pedagogical and ethical competences, exactly as Arras et al. (2011) reported. The frequency of using a computer connected to the Internet at home suggested a higher level of competences, essentially technological and pedagogical ones but not for ethical competences. These results partly coincide with those found in other studies (Baturay et al., 2017; Castaño et al. 2012; McCoy, 2010; Nami & Vaezi, 2018; van Braak, 2004; Yalman et al., 2016). Accordingly, and as McCoy (2010) pointed out, access to technological resources at home and their increased use indicate an increase in ICT competences. The area where the degree is taught was a factor that also influenced the subsets of competences, and in such a way that the more related the degree was to the education domain, the higher the level of technological and ethical competences, but not pedagogical ones. This reinforces other studies that have found differences among different university degrees in ICT competences in accordance with the particular field of study (Castaño et al. 2012; Nami & Vaezi, 2018; Tien & Fu, 2008; Verhoeven et al., 2016). This would be an interesting topic to investigate in the future.

Age, university admission test's mark and curricular course were the univariate factors that were related with ICT competences, as other studies have indicated for age (Cabezas-González et al., 2016; Castaño et al., 2012; McCoy, 2010), mark (Tien & Fu, 2008) and curricular course (Kaminski et al., 2009). In multivariate terms, the three aforementioned factors did not determine any strong influence on the three subsets of competences. Nonetheless, both age and curricular course came close to the acceptance area (about 0.10) for the influence of pedagogical competences. This must be considered sufficient evidence to closely explore it in other situations because it would back the interest shown in how students evolve as regards their competence-based profile throughout their careers.

Conclusions

The present study validated a basic ICT competences model made up of three subsets (technological, pedagogical, ethical) with university students in the education domain. Likewise, these three subsets of competences was asymmetrically linked, so that both technological and ethical competences influenced pedagogical ones, but technological competences did so more intensely.

Thus, pedagogical competences become an important component of the ICT model (Knezek and Christensen, 2016), close to the concept of digital fluency (Alexander et al., 2019). Likewise, ethical competences form a subset with their own dimensionality in ICT competences (Law et al., 2018).

In addition, the relation linking the personal and contextual factors indicate a complex influence with ICT competences (Aesaert et al., 2015; Lim et al., 2013). Thus, it is reasserted that ICT competences are developed in socio-cultural environments (Alexander et al., 2016).

This study has its limitations because it was conducted with a non-probabilistic sample and focused on students in the education domain. Hence, these limitations must be considered before generalising the results, corroborating this ICT competences model with other larger samples and degrees from other areas.

Future research should contemplate other constructs that can be included in the model, such as attitudes to ICT (Knezek & Christensen, 2016) and the technology acceptance model (Baturay et al., 2017; Huffman & Huffman, 2012; Nami & Vaezi, 2018) because, for both cases, relations were found with ICT competences. Likewise, the use of ICT should be considered just as other studies have done (Tien & Fu, 2008; Verhoeven et al., 2016), and the competences model ought to be included in other models (Huffman & Huffman, 2012; Knezek & Christensen, 2016).

Regarding educational implications, this study allows the design of training plans for university students that fit their needs, acquiring an adequate level of mastery in the three ICT competence subsets. The mastery of technological resources is just as important as mastering information management to create knowledge from an ethical viewpoint (Alexander et al., 2016; Spante et al., 2018). On the other hand, the asymmetric relationship between the three subsets of competencies means that technological competencies have to temporally precede pedagogical competencies in the training of university students (Krumsvik, 2011; Mooij & Smeets, 2001). Likewise, ethical competencies encompass the other two subsets of competencies (technological and pedagogical) because good use of technologies requires knowing how and when to use them (Alexander et al., 2016; Krumsvik, 2011).

Author contributions

All authors contributed to the design, development and writing of the article.

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