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Pre-Service Teachers, Computers, and ICT Courses:
A Troubled Relationship

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ABSTRACT

The study presents the results of a four-year long survey among pre-service teachers, examining factors which influence their knowledge and skills on computers, as well as factors which contribute to shaping their perceived computer competency. Participants were seven hundred fifty-four senior students, at the Department of Primary School Education, University of the Aegean. Results analyses, using multiple linear regression, indicate that pre-service teachers do not actually know much about computers and that they base their perceived competence on computers mainly on how skilled they believe they are in office applications. Results also indicated that the number of ICT related courses students attended contributed, to some extent, in knowledge acquisition but did not influence their perceived computer competency. Based on the results, recommendations are made in order/so as pre-service teachers to be more adequately prepared to meet the challenges of using ICT at school.

KEYWORDS

ICT Courses, Knowledge and Skills on Computers, Perceived Competence on Computers, Pre-service Teachers

INTRODUCTION

Despite the fact that ICT has been introduced in education for quite a while, it is still underused (Mueller, Wood, Willoughby, Ross, & Specht, 2008). According to the results of Schoolnet's survey (2013), conducted in all EU's countries, teachers consider insufficient equipment as the major obstacle to ICT use. On the other hand, no relationship was found between high levels of infrastructure and teachers' use. Most teachers, even though they state that they are familiar with computers, confident in using ICT, and positive about ICT's impact on students' learning, they still use computers merely to prepare their teaching. Interesting is the fact that the more confident teachers are in using ICT, the more frequently they get involved in ICT-based activities during lessons. Another extensive survey, featuring data from 64 countries, has concluded that the impact of technology on education is yet to be realized (Organisation for Economic Co-operation and Development-OECD, 2015). There are still significant drawbacks such as the tendency of educators to avoid changes, the insufficient policy design and implementation strategies, and the poor understanding of the relationship between ICT and pedagogy. The study makes an interesting suggestion: teachers have to become active agents of change, not just tools for implementing technological innovations, but also capable of designing them.

From the above, it is evident that educators hold the key to the successful integration of ICT in education because they are the ones that are called to make good use of computers and to implement policies. Literature suggests that major predictors in determining if teachers will use computers in

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teaching are their views and beliefs on the matter (Fessakis & Karakiza, 2010) and their attitude towards computers (i.e., Celik, & Yesilyurt, 2013; Teo, 2011; Paraskeva, Bouta, & Papagianni, 2008). To influence these attitudes, in-service training is suggested (Schoolnet, 2013; Goktas, Yildirim, & Yildirim, 2009), but also one has to start as early as possible, at the pre-service level. Pre-service teachers have to have well-developed ICT skills and adequate experience on tools that will be useful in their future profession. Universities have the responsibility to positively influence their attitudes and adapt the curriculum so as to sufficiently prepare them to meet the challenges of using ICT at school (Koehler & Mishra, 2009).

The fact is that universities' curricula vary enormously within and between countries (Darling-Hammond & Baratz-Snowden, 2005) and ICT practices vary even more (Law & Plomp, 2003). Nevertheless, Davis (2010) specifies five strategies that have been commonly implemented in order to develop the pre-service teachers' ICT skills, knowledge of technologies, and the ways that ICT may be effectively applied in schools: (a) stand-alone technology courses, (b) workshops, (c) integrating ICT in method and foundation courses, (d) modeling how to use ICT, and (e) practicum in schools that include ICT.

All Greek departments of primary school education incorporate a number of ICT courses into their curricula. Students have to attend mandatory and elective courses which provide them with basic and advanced ICT knowledge and skills, as well as courses closely related to ICT uses at school. In general, all the strategies indicated by Davis are applied. For example, 13% of the courses that are offered at the Department of Primary School Education, University of the Aegean, are ICT orientated. Considering the multidisciplinary nature of teachers' studies, this percentage is quite high. Similar is the situation in all the other Greek departments of education, with percentages varying from 8 to 13%. This indicates that universities acknowledge the importance of adequately preparing pre-service teachers to integrate ICT into their future profession.

The above ascertainment, however, raises a number of reasonable questions:

- What students have actually learned after having attended all the ICT related courses? In other words, what is their actual ICT knowledge and skills level?
- Do students consider themselves competent in using computers? Do they consider themselves competent in all the categories of software tools that allow the development of educational applications?
- What factors influence the above? Do ICT courses play a substantial role?

The present study is an attempt to clarify these matters. It is important to give answers to these questions because in case the curriculum fails in achieving its goals, this will result in students not being skillful in ICT, but also their perceived ICT self-efficacy might be affected. These two factors, combined together, can lead to the underuse of computers at the in-service level (Kumar & Kumar, 2003). Furthermore, the study at hand, is a longitudinal study, examining senior students' knowledge, skills, and perceived self-efficacy across the years 2012 to 2015. To the best of the author's knowledge, there are no previous studies -at least in Greece- longitudinally examining similar parameters.

METHOD

The target group was students attending the final year of their studies at the Department of Primary School Education, University of the Aegean. Senior students were selected because, at this stage, they have already attended most of the courses (including ICT-related ones). The study was conducted from late 2012 to late 2015, gathering data from the 93% of senior students (754 valid responses out of 807 total graduates). Also, the sample represents roughly 10% of the total number of students that graduated from all Greek departments of primary education (around 7,200) at the same period of time. Therefore, the study is a good indicator of the situation in Greece, given that -more or less- all departments of education have similar ICT related curricula.

A self-report questionnaire was designed and used in this study, in an attempt to document pre-service teachers' actual and perceived competence in computers. It included the following questions' categories:

- Demographical data (4 items).
- A short test for evaluating participants' actual knowledge and skills on computers (12 items). All questions were related to common tasks a user has to perform quite often (i.e. uninstall a program, end a task, change his/her password).
- Computer usage and patterns (20 items). There were questions (a) on the number of ICT related courses students attended, (b) other types of ICT-related training they received, (c) hours per day of using computers, (d) the electronic devices they use (i.e., mobile phones, tablets, game consoles), (e) the number and type of accounts they have (i.e., Facebook, Gmail, Youtube), and (f) for what purposes they use computers (i.e., social networking, academic/assignments, entertainment).
- Perceived competence in computers and in the educational uses of software tools (10 items). During their studies, students learn to use a minimum of 9 software tools, which fall into 3 major categories: (a) office applications, (b) Internet applications authoring tools, and (c) multimedia applications authoring tools. Students were asked to evaluate themselves on how skilled they believe they are in each one of them (on a scale from 0 to 5). They were also asked to give an overall assessment of their computer competence (on a scale from 0 to 10).

The questionnaire was administered online. Each participant could complete it once and thereafter changes were not possible. A two-step login procedure was followed in order to ensure anonymity but also the integrity of the data. Each student had to login to the site that the questionnaire was available, using his/her university credentials (user name and password), before being redirected to the questionnaire. The credentials were then deleted from the database that contained all users, so a user could not login again. All questions were mandatory and it was checked whether they were answered.

RESULTS

Descriptive Statistics

As already mentioned, the sample was 754 pre-service teachers. The majority (81.2%) were females and 90.2% of them were at the age range of 21-24 ($M = 22.77$, $SD = 3.44$), reflecting the actual gender and age distribution of students. The distribution of participants was almost even across the years that the study lasted (2012, $N = 192$; 2013, $N = 185$; 2014, $N = 190$; 2015, $N = 187$). Although there are 11 ICT related courses, none has attended more than 8 ($M = 6.37$, $SD = 1.04$), while a 23.1% has received additional ICT training (i.e., ECDL courses).

Students use computers for around 4 hours per day ($M = 4.15$, $SD = 2.14$). They all own computers (PCs, 18.7%; laptops, 96.4%; both, 15.1%), as well as mobile phones (69.2% one mobile phone/number, 30.8% two or more mobile phones/numbers). Apart from mobile phones, they do not own or use many other electronic devices ($M = 1.84$, $SD = 1.02$), with game consoles ($N = 100$), portable game consoles ($N = 46$), iPods ($N = 51$) and tablets ($N = 62$), being the most common. Time spent using a computer is interesting. While a 22% of the time is allocated to assignments ($M = .22$, $SD = 0.13$), a third is for entertainment (watching movies and listening to music) ($M = .32$, $SD = 0.13$) and another third is allocated to social networking ($M = .31$, $SD = 0.13$). Gaming takes around 9% ($M = .09$, $SD = 0.10$) and 6% of the time is for other uses ($M = .06$, $SD = 0.09$). Most students have 3 to 4 Internet and social media accounts ($M = 3.55$, $SD = 1.55$), with Facebook being the most popular (89.9%), followed by Gmail (67.9%), Hotmail (63.5%), Youtube (37.5%), Yahoo

Mail (20%), Google Blogger (16.2%), and Twitter (14.5%). Other services, like MySpace, Flickr, and LinkedIn, are far less popular (< 2.5%).

Actual knowledge and skills on computers, hereafter AKSC, was computed based on participants' correct answers in the relevant questions (*min* = 0, *max* = 12, *M* = 4.83, *SD* = 1.97). A number of questions had quite high percentages of wrong or no answers. For example, 51.5% of the students did not know how to change their password, a 49.4% ignored how to uninstall a program, a 45.4% did not know how to update the operating system, and a 25.6% did not know how to end a task. On the other hand, students' overall perceived competence in computers, hereafter PCC, was above the mid-point (*min* = 0, *max* = 10, *M* = 5.20, *SD* = 1.38). Perceived competence in office applications (PCO) was quite high (*min* = 0, *max* = 15, *M* = 9.59, *SD* = 2.75). Considerably lower was perceived competence in multimedia applications authoring tools (PCM) (*min* = 0, *max* = 15, *M* = 6.72, *SD* = 2.59) and perceived competence in Internet applications authoring tools (PCI) (min = 0, max = 15, *M* = 5.92, *SD* = 2.50).

Multiple Linear Regression Analysis

In order to discover what might explain scores on AKSC and scores on PCC, multiple linear regression analysis was applied. In two separate analyses using the stepwise method, AKSC and PCC scores were entered as dependent variables (DVs). The following questionnaire's items were used as independent variables (IVs): (a) the year that the questionnaire was filled, (b) age, (c) gender, (d) hours using computers, (e) ownership of PC, laptop or both, (f) the number of accounts one has, (g) the number of electronic devices he/she owns, (h) the number of attended ICT courses, (i) if one has received additional ICT related training, (j) the percentage of computer usage for assignments/work, entertainment, social networking, games, and other, and (k) the scores on PCO, PCI, and PCM. Also, ones AKSC score was used as an IV for predicting his/her PCC score and vice versa.

There were no missing data or unengaged responses. The rule of thumb for at least 20 participants per each IV (Hair, Anderson, Tatham, & Black, 1998), was satisfied since there were 754 participants and 23 IVs. An analysis of standard residuals was carried out, which showed that the data contained no outliers, since there were no values exceeding the |3| limit (Field, 2009) (Std. Residual Min = -2.71, Std. Residual Max = 2.81 for AKSC, and Std. Residual Min = -2.69, Std. Residual Max = 2.63 for PCC). The data met the assumption of independent errors (Durbin-Watson statistic = 1.99 for AKSC and Durbin-Watson statistic = 2.02 for PCC). The histograms of standardized residuals indicated that the data contained approximately normally distributed errors, as did the normal P-P plots of standardized residuals, which showed that points were not completely on the line, but very close (Figures 1-4).

Multicollinearity was checked using Variance Inflation Factor (VIF) and tolerance. There were no cases where VIF exceeded 1.50, satisfying even the strict value of 4 as a recommended maximum (Pan & Jackson, 2008). Similarly, the minimum value of tolerance that was observed was .67 (> .85 for the IVs that were included in both models), well above the recommended minimum of .25 (Huber & Stephens, 1993). The data also met the assumption of non-zero variances. Finally, heteroscedasticity was checked using the Breusch-Pagan test (Breusch & Pagan, 1979). It was found that while PCC data were homoscedastic [$\chi^2(5) = 10.36$, $p = .07$], heteroscedasticity was an issue on AKSC [$\chi^2(4) = 45.49$, $p < .001$]. Since there was heteroscedasticity in the residuals of the AKSC scores, heteroscedasticity consistent standard errors were estimated for the IVs that were included in AKSC's final model (Hayes & Cai, 2007).

After conducting the analyses, it was found that:

- The number of ICT courses one has attended, if he has received additional ICT training, ownership of both a PC and a laptop, and if computers are used for gaming, explain a relatively small amount of the variance in AKSC scores [$F(4, 749) = 104.47$, $p < .001$, $R^2 = .36$, $R^2_{Adjusted} = .36$]. Detailed results are shown in Table 1.

Figure 1. Histogram for AKSC

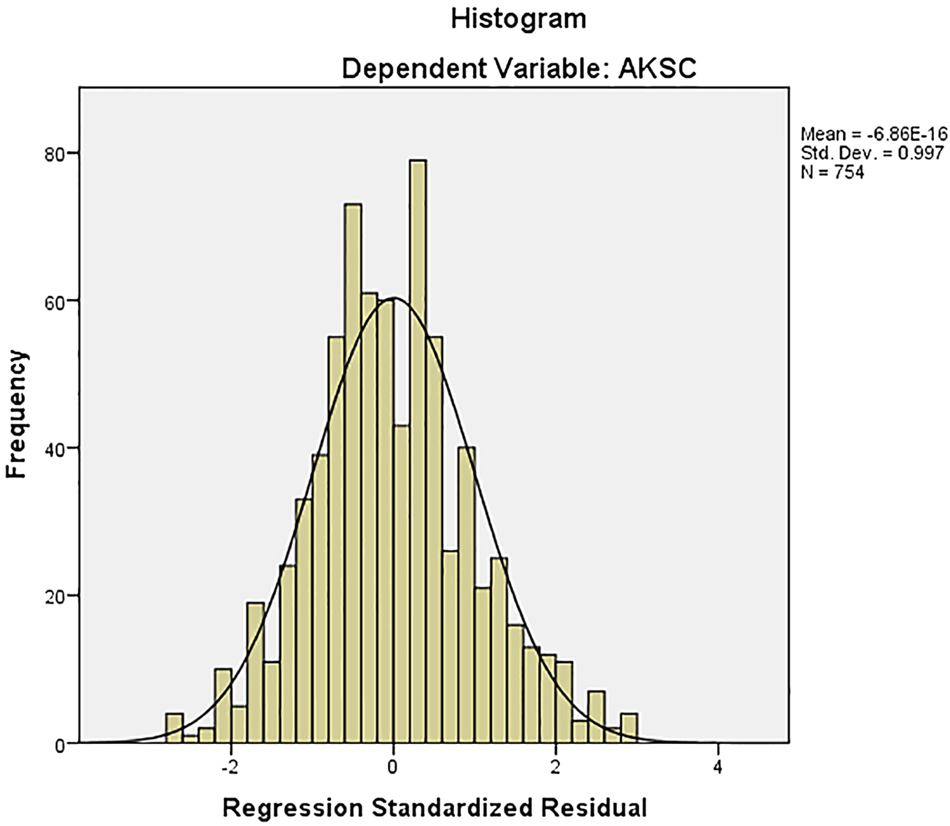

Figure 2. P-P Plot for AKSC

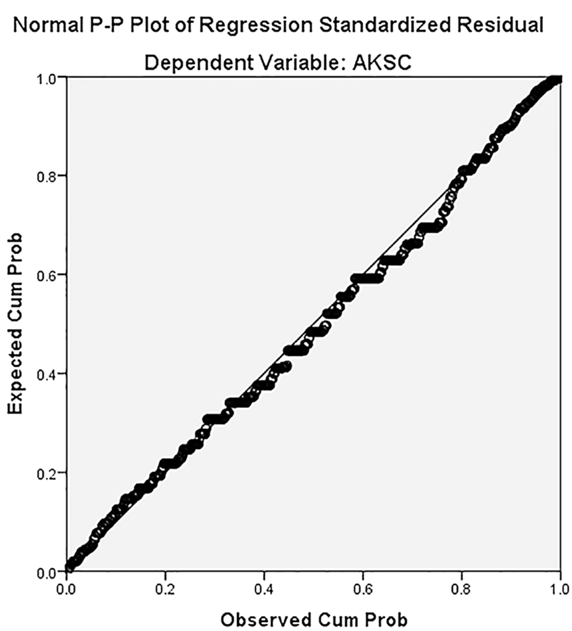

Figure 3. Histogram for PCC

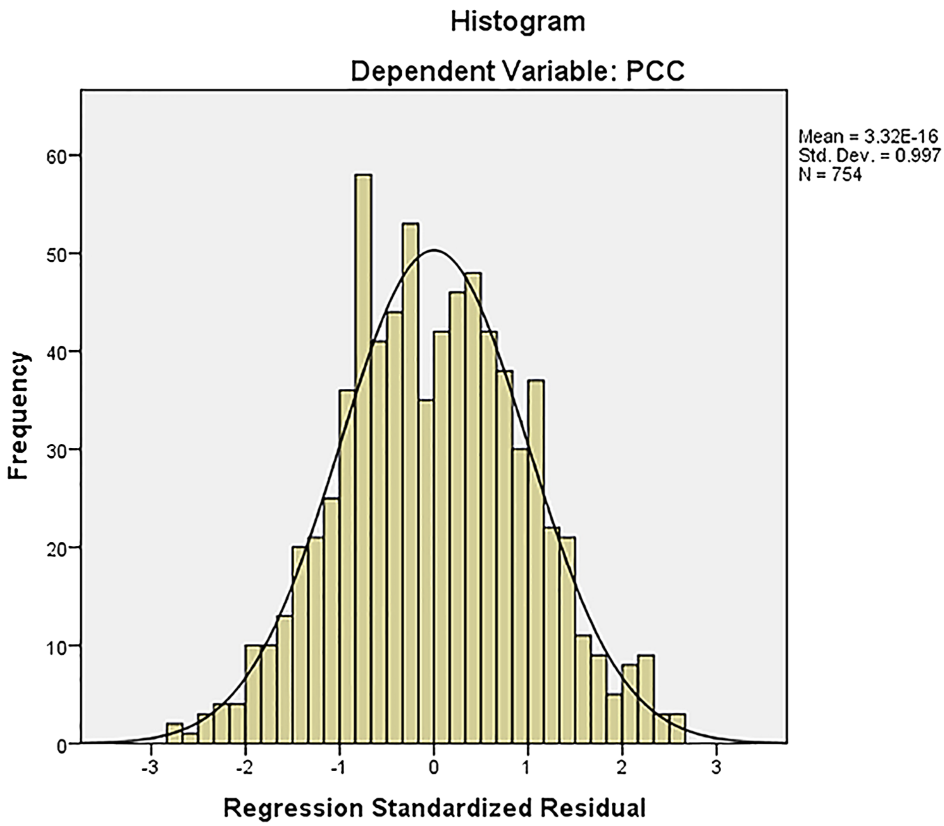

Figure 4. P-P Plot for PCC

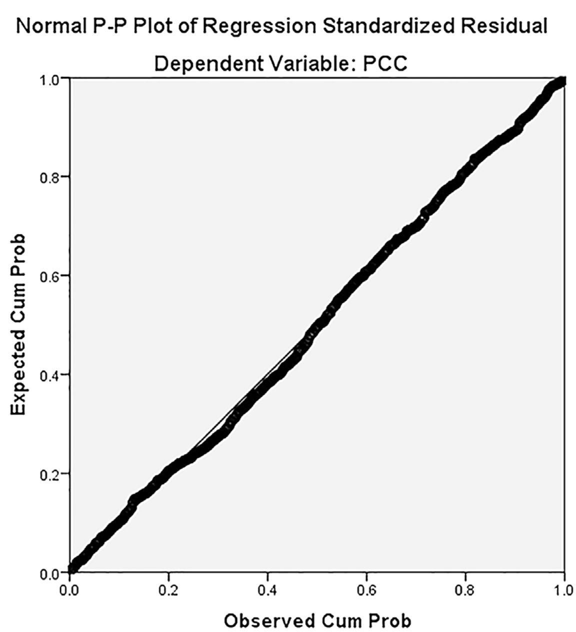

Table 1. Linear model of predictors of AKSC. 95% confidence intervals reported in parentheses

	b	*SE B*	*β*	*p*
Step 1				
Constant	4.37 (4.23, 4.52)	0.07		*p* < .001
Additional ICT Training	1.96 (1.66, 2.27)	0.15	.42	*p* < .001
Step 2				
Constant	0.47 (-0.28, 1.21)	0.37		*p* = .22
Additional ICT Training	1.70 (1.42, 1.99)	0.15	.37	*p* < .001
ICT Courses	0.62 (0.51, 0.74)	0.06	.33	*p* < .001
Step 3				
Constant	-0.95 (-1.73, -0.8)	0.39		*p* = .016
Additional ICT Training	1.42 (1.14, 1.70)	0.14	.31	*p* < .001
ICT Courses	0.59 (0.48, 0.70)	0.06	.31	*p* < .001
Own a PC & a Laptop	1.49 (1.16, 1.81)	0.17	.27	*p* < .001
Step 4				
Constant	-0.75 (-1.53, 0.04)	0.44*		*p* = .06
Additional ICT Training	1.40 (1.20, 1.68)	0.16*	.30	*p* < .001
ICT Courses	0.58 (0.47, 0.69)	0.06*	.31	*p* < .001
Own a PC & a Laptop	1.46 (1.13, 1.78)	0.21*	.27	*p* < .001
Use for Games	-1.50 (-2.58, -0.41)	0.50*	-.08	*p* = .003

Note. R^2 = .18 for Step 1: ΔR^2 = .11 for Step 2: ΔR^2 = .07 for Step 3: ΔR^2 = .006 for Step 4 (*ps* < .05).
* Heteroscedasticity consistent standard errors

- PCO, PCI, and PCM, the number of accounts one has, and if computers are used for gaming, explain a sufficient amount of the variance in PCC scores [$F(5, 748) = 214.12$, $p < .001$, $R^2 = .59$, $R^2_{Adjusted} = .59$]. Detailed results are shown in Table 2.

DISCUSSION

Pre-service teachers, even though they do not own many electronic gadgets, they all own computers (laptops being the predominant type). They also seem to be quite active computer users; they spend around 4 hours a day using computers and they have more than 3 mail and social media accounts. When using computers, a fifth of the time is allocated for academic purposes, while a third is for entertainment and another third is for social networking. This finding is in line with studies which show that undergraduate students use computers for socializing, personal web services and entertainment, far more frequently than for academic purposes (Sim & Butson, 2013; Margaryan, Littlejohn, & Vojt, 2011).

Scores regarding actual knowledge and skills on computers were somewhat disappointing ($min = 0$, $max = 12$, $M = 4.83$, $SD = 1.97$). Given that the questions were simple and related to tasks and problems a user often faces when using computers, results were expected to be better. This finding is alarming. It indicates that pre-service teachers do not actually know much about computers. It seems that while they make extensive use of computers, conducting some basic activities, like using the email or surfing on the Internet, their technological background is shallow and problematic, as other studies have pointed out (Dahlstrom & Bichsel, 2014; Kvavik, 2005). Moreover, almost all the relevant questions reflected matters discussed in courses aiming in providing students with ICT knowledge and skills. Therefore, the low AKSC scores also indicated that these courses have not achieved their objectives.

Students' perceived competence in computers was slightly above the midpoint ($min = 0$, $max = 10$, $M = 5.20$, $SD = 1.38$). This means that students view themselves as "average" computer users. This is

Table 2. Linear model of predictors of PCC. 95% confidence intervals reported in parentheses

	b	*SE B*	*β*	*p*
Step 1				
Constant	1.69 (1.44, 1.93)	0.13		$p < .001$
Perceived Competence Office Applications	0.37 (0.34, 0.39)	0.01	.73	$p < .001$
Step 2				
Constant	1.40 (1.15, 1.65)	0.13		$p < .001$
Perceived Competence Office Applications	0.33 (0.31, 0.36)	0.01	.66	$p < .001$
Accounts	0.17 (0.13, 0.22)	0.02	.19	$p < .001$
Step 3				
Constant	1.27 (1.01, 1.52)	0.13		$p < .001$
Perceived Competence Office Applications	0.31 (0.28, 0.34)	0.01	.62	$p < .001$
Accounts	0.15 (0.11, 0.20)	0.02	.17	$p < .001$
Perceived Competence Multimedia Tools	0.06 (0.04, 0.09)	0.01	.12	$p < .001$
Step 4				
Constant	1.22 (0.97, 1.47)	0.13		$p < .001$
Perceived Competence Office Applications	0.31 (0.28, 0.33)	0.01	.61	$p < .001$
Accounts	0.14 (0.10, 0.19)	0.02	.16	$p < .001$
Perceived Competence Multimedia Tools	0.06 (0.03, 0.09)	0.01	.11	$p < .001$
Use for Games	1.31 (0.69, 1.92)	0.31	.10	$p < .001$
Step 5				
Constant	1.26 (1.00, 1.51)	0.13		$p < .001$
Perceived Competence Office Applications	0.32 (0.29, 0.34)	0.01	.63	$p < .001$
Accounts	0.15 (0.11, 0.20)	0.02	.17	$p < .001$
Perceived Competence Multimedia Tools	0.75 (0.05, 0.11)	0.02	.14	$p < .001$
Use for Games	1.32 0.71, 1.93)	0.31	.10	$p < .001$
Perceived Competence Internet Tools	-.04 (-0.07, -0.01)	0.02	-.08	$p = .007$

Note. $R^2 = .53$ for Step 1: $\Delta R^2 = .03$ for Step 2: $\Delta R^2 = .01$ for Step 3: $\Delta R^2 = .01$ for Step 4: $\Delta R^2 = .004$ for Step 5 ($ps < .05$).

probably an overestimation when considered together with scores in AKSC. This finding is consistent with other studies which have concluded that pre-service teachers inaccurately self-assess their digital competence (Maderick, Zhang, Hartley, & Marchand, 2015). Perceived competence in office applications was high ($min = 0$, $max = 15$, $M = 9.59$, $SD = 2.75$). On the other hand, the perceived competencies in multimedia applications authoring tools and in Internet applications authoring tools were considerably lower and well below the mid-point. In other words, pre-service teachers do not consider themselves capable in using these types of authoring software tools multimedia applications authoring software and Internet applications authoring tools. This finding suggests that the relevant courses did not influence students' perceived self-efficacy on these matters.

Results from the regression analysis are challenging. A relatively small percentage of the variation in AKSC scores (36%) was explained by four predictor variables: (a) if one has received additional ICT training ($\beta = .30$), (b) the number of ICT courses he/she has attended ($\beta = .31$), (c) the ownership of both a PC and a laptop ($\beta = .27$), and (d) if computers are used for gaming ($\beta = -.08$). Each of the first three predictors explains about a third of the variance, while use for gaming has a negative impact, although a small one. Interestingly enough, variables such as age, gender, hours of computer usage, and other patterns of computer usage, were not included in the final model. Since the model has a limited explanatory power and the number of ICT courses one has attended explains just a third of the variance, it can be assumed that ICT courses do play a role in one's general knowledge of computers, but their impact is relatively small.

In contrast, a sufficient amount of the variation in PCC scores (59%) was explained by five predictor variables: (a) PCO ($\beta = .63$), (b) the number of accounts one has ($\beta = .17$), (c) PCM ($\beta = .14$), (d) if computers are used for gaming ($\beta = .10$), and (e) PCI ($\beta = -.08$). Evidently, if one considers himself competent in office applications, he also considers himself competent in computers in general. Age, gender, and hours of computer usage, as one might have expected, were not included as significant predictors. The number of ICT courses one has attended was also not included as a predictor variable. It seems that the number of ICT related courses one has attended fails to influence his/her subjective competence in computers. One might argue that the other relevant to ICT courses subjective competencies (PCM and PCI) were included in the model. However, the explanatory power of perceived competence in multimedia applications authoring tools is far less important than that of perceived competence in office applications and perceived competence in Internet applications authoring tools has a negative impact. It is important to keep in mind that office applications are not used just in ICT related courses, but, virtually, in all courses. This means that students use them all the time, and this, in turn, makes them feel computer literate.

CONCLUSION

Literature suggests that teachers' beliefs about their computer efficacy predict if they will use computers during their teaching (i.e., Wozney, Venkatesh, & Abrami, 2006). Also, their lack of knowledge and skills on computers, together with low perceived competence, can impede the successful integration of technology in schools (Paraskeva, Bouta, & Papagianni, 2008; Kumar & Kumar, 2003). Teachers' knowledge, skills, and subjective competence, can be shaped or influenced either with in-service interventions (i.e., training seminars) or at the pre-service level while they are still studying to become teachers. Thus, it is quite reasonable to examine: if students consider themselves competent in using computers, how computer literate they actually are, what factors influence their knowledge, skills, and subjective self-assessment, and, finally, the impact of the ICT related courses they attended to the above.

The target group was senior students, about to complete their studies. It can be assumed that their knowledge, skills, and perceived competencies on computers must have been well established by the time the study was conducted. In addition, the sample size represents a noteworthy percentage of the total number of senior students in all Greek Departments of Primary Education. Therefore, reasonably safe conclusions can be drawn. Although the study was limited in one department of education, it can be argued that its findings have implications not just to Greek, but to other departments of primary school education as well. That is because even though the universities' curricula vary enormously, they all include a number of mandatory and selective ICT courses and, more or less, they all implement the same strategies in order to develop the pre-service teachers' ICT knowledge and skills, and the ways that ICT may be effectively applied in schools, as Davis (2010) suggested.

Putting together the results, they formulate the profile of a pre-service teacher that considers himself an "average" computer user, though a contradictory one: he uses a word processor, a spreadsheet, and a presentation program, he plays computer games, and he is an Internet and a social media user. The more of the above, the more he feels that he is computer literate. But, on the other hand, he does not actually know much about computers. Moreover, since scores on actual knowledge and skills were low and could not predict scores on computer competence (which were above the midpoint), it seems that students overestimate their skills. In addition, they base their assessment virtually on a single factor: how good they think they are in office applications. Therefore, it is doubtful whether subjective self-assessment can be used as an accurate stand-alone predictor of digital competence, which is also highlighted by Maderick, Zhang, Hartley, and Marchand (2015).

Examining the role of ICT courses in shaping pre-service teachers' knowledge, skills, and subjective competence, it seems that they are not so successful. Regardless of how many ICT courses one has attended, his/her perceived computer competence remains unaffected. Additionally, a significant portion of the variance in actual knowledge and skills was left unexplained and ICT courses were just a third of the explained variance. Multiple implications arise from this fact:

- There is a need to identify the other factors influencing students' knowledge and skills on computers.
- It seems that the aspiration of rendering teachers capable of designing educational applications (OECD, 2015), is far from being accomplished. One that lacks basic ICT skills and also does not consider himself capable of using multimedia and Internet applications authoring tools will use computers just to prepare his teaching (i.e., lessons' plans) and will hardly get involved in more complex and demanding tasks, as Schoolnet's survey (2013) has pointed out.
- Taking into account that the study lasted for four years and the relevant IVs were not included in either model, it seems that the situation has not changed through the years; pre-service teachers become in-service teachers having the same low knowledge and skills level and the same beliefs regarding their computer competency. It is quite logical when they face difficulties in incorporating ICT into their practice, to simply revert to traditional teaching methods (Tziafetas, Avgerinos, & Karakiza, 2013) and in-classroom computer usage to become occasional or even non-existent (Koustourakis & Panayiotakopoulos, 2008).

There are also implications for the ICT courses per se. In order to be more effective, the following can be considered:

- Students studying at the departments of primary education in Greece have a theoretical background; in High School science and technology subjects played an unsubstantial role in their education (Stamelos & Emvalotis, 2001). This given fact, together with the poor knowledge and skills level, point to the need for establishing a well-grounded technological background, probably prior to studying courses related to the educational uses of ICT. Seminars and workshops providing hands-on experiences will be useful in establishing a much-needed technology orientated pre-service teachers' culture.
- Even though subjective self-assessment cannot be used as a predictor of digital competence, it may prove a useful indicator when designing pre-service teachers' training programs, such as the above. By knowing what the students' beliefs are, one can direct them towards reflecting upon their perceptions and their actual knowledge and skills (Maderick, Zhang, Hartley, & Marchand, 2015).
- Technology should be incorporated throughout the curriculum and should be linked to practice (Jang, 2008; Brush et al., 2003), providing experiences on how it can be applied in specific content areas (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). It is good to have a large number of ICT related courses in the curriculum, but universities have to examine whether these courses conform to the above and, if not, to re-design them.
- Students' attitudes appear to be influenced by their lecturers (Margaryan, Littlejohn, & Vojt, 2011) and expect their teachers to train them on how to use technology (Dahlstrom, Walker, & Dziuban, 2012). It is the lecturers' task to be a role model for students and to provide a frame of reference, by adopting and demonstrating innovative approaches to technology-enhanced learning.

There are limitations to this study that need to be acknowledged. Even though all necessary precautions were taken, one can never be certain regarding the reliability or the accuracy of the participants' responses. Factors that substantially influence pre-service teachers' knowledge and skills on computers need to be further investigated in order to obtain a model with better explanatory power. Also, the study was limited only to Greek pre-service teachers. Comparative studies across countries could be conducted to identify differences or similarities to the findings of the present study. It would also be interesting to examine whether perceived competence on computers can be included as a factor in a model of users' acceptance and usage of technology, like Technology Acceptance Model (Davis, Bagozzi, & Warshaw, 1989). Nevertheless, the study's results might prove useful to universities in adapting the curriculum so as to sufficiently prepare pre-service teachers to meet the challenges of using ICT at school.

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