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Teachers and Technology: A Complicated Relationship

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Abstract— **Although technology is present in most classrooms and many countries have made strong recommendations for ICT integration in schools and teachers' practices, a great number of teachers do not use ICT in their educational activities. Research has provided theories and models that explain the consistency of the relationship between attitudes and behavior. These theories converge to identify common aspects that foster technology integration.**

We now propose an "ICT Skills Towards Technology Use" (ISTTU) model to evaluate the impact of "ICT Knowledge" over "Intention to Use ICT" (IUICT). Based on previously validated questionnaires, we have developed a questionnaire that was applied to a sample of teachers from the vocational stream of secondary education in Portugal. The data was tested and evaluated using Structural Equation Modeling techniques and we concluded that "ICT Knowledge" is a good predictor of the "IUICT" and that "teaching area" has an impact on "Intention to Use ICT". We also concluded that "gender" and "Learning through ICT" have no significant impact on IUICT. The ISTTU model shows that fostering the development of ICT skills (increasing "ICT Knowledge") will develop the "intention to use technologies with students".

Keywords-component; ISTTU Model; Structural Equation Modeling; Technology Acceptance Models; Technological Knowledge; Teacher's Professional Development.

I. INTRODUCTION

Integrating Information and Communication Technologies (ICT) in education has been one of the most debated issues of the past decade and has become an increasingly high priority for decision makers throughout the world. Although a significant effort has been made in terms of school equipment and teacher training all over the world [57] [42] we are still observing an underachievement in terms of ICT integration in classrooms. By analyzing research made in the last few years, we may conclude that technology is still peripheral to most teachers' practices [8]. We know that technology has a significant role in today's students' lives, although "digital comfort" is not synonymous of "digital proficiency" [11] [12] as young people digital skills are far from uniform. This means that, generally, young people may be more comfortable with technology, mainly social software [9], but reveal difficulties when asked to perform complex operations with it [26].

Nowadays, as Miranda described a few years ago [15] "the effective use of technology in the classroom and the introduction of Virtual Learning Environments (VLE) is still a privilege of a few teachers and students" (p.48). In fact, the huge development of classroom technologies during the last 30 years, made clear the resistances that teachers still reveal about changing their practices. Although technology is now widely available and cheaper than ever, the most commonly used technology in terms of teaching strategies are still "Chalk and Talk" [41] (p. 283). As Moran [28] stresses (p. 69), "we dump technology into universities and schools but, in general, we still do what we always did – the teacher speaks and the student listens – but now with a varnish of modernity. Technologies are now used to illustrate teachers' speech, instead of creating new and challenging leaning opportunities".

Therefore, to equip schools with digital technologies is necessary, but it may not be sufficient. According to Miranda [15] "research has demonstrated that the strategy of adding technology to current classroom activities without changing the teaching methods does not produce satisfactory outcomes in student achievement" (p.44) (cf. De Corte, 1993; Jonassen, 1996; Thompson, Simonson & Hargreaves, 1996)".

Many countries have made recommendations for ICT integration in schools and on teachers' practices, published in white papers [1] [12] in order to emphasize how technology can facilitate student learning [32] [27] [48]. Like many other countries, Portugal subscribed the "Education 2015 program", a milestone for the goals defined by the Iberian-American states for the year 2021. This program establishes the objectives for educational policies and school equipment but, more importantly, it sets the stage for an increasing focus on lifelong learning, the cornerstone of teachers' professional development. This statement may become a crucial element to change teachers' practices. Teachers' ICT use, in order to promote student learning, demands time, work, availability and willpower.

This goal if far from being achieved and the reasons may be: a) the fact that ICT integration is not a compulsory request to obtain teaching qualifications; b) the lack of digital proficiency that may enable teachers to overcome their own ICT usage difficulties; c) the insufficient weight given to ICT knowledge and ICT training in pre-service teacher education; d) the inadequacy of lifelong training programs, often built to provide career progression rather than providing the professional development that teachers need for a better performance in service; e) the attitude towards technology, albeit behavior is not determined only by the attitudes of individuals, but also by social norms, habits, and behaviors expected consequences [49] [17].

In 2009, Usun suggested that "Teachers need support and training to positively integrate technology into their classroom and teacher's attitudes toward ICT may be a significant factor in the implementation of ICT in education" (p.331) [53].

Several theories and models have tried to explain the consistency of the relationship between attitude and behavior. Some of them tried to explain the teachers' technology acceptance and its influence over the behavior to adopt and integrate ICT in classroom activities. The most well-known are: (i) TRA (Theory of Reasoned Action) - developed a model

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for the prediction of behavioral intention considering “attitude” and “behavior”. This theory stated that “behavior” is preceded by the “behavioral intention” and that “attitude towards behavior” and “subjective norm” (other people’s opinion related to “our” behavior) are triggers to develop “behavioral intention” as described in the TRA model [37]; ii) The TPB (Theory of Planned Behavior) is an extension of TRA adding another variable (Perceived Behavioral Control) to the other predictors. In this theory, the combination of "attitude towards behavior," "subjective norm," and "perceived behavioral control" leads to the formation of "behavioral intention” as described in the TPB model [18]; iii) The TAM (Technology Acceptance Model) suggests that when users are introduced to a new technology, they are influenced by a number of factors on how and when they will use it, notably “Perceived Usefulness” (the degree to which a person believes that using a particular system would enhance his or her job performance) and “Perceived Ease-of-Use” (the degree to which a person believes that using a particular system would be free from effort). These are the main constructs of this model, but its evolution added external variables and moderators that influenced “Perceived Usefulness”, “Perceived Ease-of-Use” or even “Behavioral Intention” as described in the TAM Model [13] [55]; iv) The UTAUT model (Unified Theory of Acceptance and Use of Technology) aims to explain the “intention to use” and the “use” of information systems. This theory holds that the direct determinants of usage intention and behavior are: “performance expectancy”, “effort expectancy”, “social influence”, and “facilitating conditions”. Other variables like “gender”, “age”, “experience”, and “voluntariness of use” have an impact on the key constructs on usage intention and behavior as shown in the UTAUT Model [56].

All these theories converge to identify “Perceived Usefulness” and “Perceived Ease-of-Use” as the common factors that foster “intention to use ICT”. If a teacher perceives that technology is “easy to use” and “useful” he will probably accept it (and integrate it) in his/her practice. Additionally, if a particular technology promotes better results in students’ learning and academic achievement, it may be a good reason to integrate it as well. However, aspects like the “dichotomy between teachers’ ICT skills and students’ ICT skills” [7] must also be addressed, as teachers usually do not feel confident when they leave their “comfort zone”. In fact, many teachers declare to avoid using ICT in classes because they fear to lose the control of the teaching process. This fact may generate anxiety and the decreasing of self-confidence related to ICT.

According to Zhou et al. [45], along with the intention of ICT use, the desire to further learning shows that teachers have, in fact, the intention to use it in the near future. So, the questions we must address are: why does is happen? Why do teachers declare to have the will to use digital technologies with students, and why this is not traduced in a consistent and satisfactory practice? Clearly we are not preparing teachers (both pre-service and in-service) to a society that is strongly marked by technologies, nor are we providing them with the conceptual tools and the technical skills that allow them to rethink their teaching processes to contemplate technology integration.

In the mid-80s, by presenting the pedagogical content knowledge framework (PCK), Shulman [34] suggested new directions for effective teaching: “By integrating content and pedagogy, teachers are best able to anticipate students’ learning needs for a particular topic, select the optimal instructional approach and understand how to scaffold the learning experiences for students” (p.84) [38]. This new approach triggered the redesign of teachers’ educational programs, integrating these two pillars together in teachers’ training. Back in the 80s, the concept of technology was probably not mentioned in Schulman’s articles as it was not a commonplace in every school; the technologies used in this decade in most schools, were also not even considered as true technologies (e.g. textbooks, overhead projectors, periodic table charts). In 1987, Shulman [35] argued that “the goal of teacher education is not to indoctrinate or train teachers to behave in prescribed ways, but to educate them to reason soundly about their teaching as well as to perform skillfully” (p.13). We would say that this statement is still valid today and what have changed are the skills that teachers need to develop. In 2006, Mishra & Kohler added a third pillar to PCK, the Technological Knowledge, stressing the need to empower teachers to take advantage of technology affordances to support a pedagogical strategy to deliver content in a class. The TPACK model was described by Mishra & Kohler [44] as “an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students’ prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones” (p.1029).

Although most of the studies may agree that these aspects should be addressed in initial training, facts have shown that the efforts made to integrate technology in teachers’ training curriculum in universities are insufficient and, until now, the results are far from satisfactory [14] [2] [51]. It should be easier to induce changes in behavior through professional development rather than waiting that universities are capable of introducing profound reforms in common practice and to induce the necessary curriculum changes to integrate ICT knowledge.

The literature review on “ICT use” led us to wonder if “ICT Knowledge” may be the missing element that can empower teachers to use the panoply of digital tools available today. We pondered if teachers’ integration of technology on their educational practices can be achieved by providing “ICT Knowledge” and “Learning through ICT”. Those two constructs combined, may develop the confidence that most teachers need to incorporate technology as a tool to improve their educational practices. Moreover, teachers should be encouraged to produce and share their digital resources in an open repository that can serve both, students and teachers.

Nevertheless, other aspects should be considered as influential factors towards the integration of technology in teaching activities: 1) the course design to foster professional development in line with TPACK suggestions [44] not dissociating the PCK (Pedagogical and Content Knowledge) from the TK (Technological Knowledge); 2) the development of online courses that may fit the needs of teachers, eliminating identified constraints like “cost”, “time” or “distance”, preserving most of their daily routines; 3) providing some complementary activities, in their own context, that may enable the development and sharing of digital educational resources that they can use in their teaching activities, in a learning environment which tends to be mostly “active”; 4) providing some opportunities for collaboration and discussion among teachers. These elements combined can foster ICT integration [39]. Although it is widely accepted that individuals’ behavioral “Intention to Use ICT” is determined by “Perceived Usefulness” and “Perceived Ease-of-Use” [55] in this study we hypothesized that teachers’ “ICT Knowledge” is a strong predictor of “Intention to Use ICT” (IUICT). This is very important as “Intention to Use ICT” is the strongest factor that fosters “ICT use” [56].

Thus, we developed and tested a causal model, called ISTTU - ICT Skills Towards Technology Use (described in figure 1) where we hypothesized that: (H1) “ICT Knowledge” (ICTK) and (H2) “Learning through ICT” (LTICT) are strong predictors of the “Intention to Use ICT”.

Additionally, we hypothesized that “Gender” (H3) and “Teaching Area” (H4) may influence the effect of “Learning through ICT” and “ICT Knowledge” over “Intention to Use ICT”.

II. METHODS

A. Design

An online survey was available from May to June of 2011, and was sent an email requesting teachers’ participation in all 208 professional schools in Portugal. APA ethical standards were followed, with a previous written informed consent form explaining the aim and scope of the study – and the acceptance of these terms was mandatory to access the questionnaire. The survey was anonymous, but was available an optional identification section for those who manifested the desire to receive further information about this study.

B. Participants

The population of our survey (teachers from 208 private Professional Schools in Portugal - a vocational stream of secondary education) was determined from data available from the Portuguese Ministry of Education (N=7293) and we obtained a total of 571 answers. It was established an inclusion criterion to consider only the completed answers (no “missing” data) and were dropped 126 responses. Therefore, we obtained n=444 completed answers, from 67 different schools, which is a quite large sample, but not necessarily representative as we could not obtain national data to guarantee the stratification by important variables. The existence of multivariate outliers was determined by the Mahanalobis square distance (D^2) and were removed from the sample a total of 17 observations, resulting in n=427. Participants in the survey ranged in age from 22 to 69 years, with a mean age of 36.6 (SD=7.8). In terms of age range, 4% (n=16) of the teachers were under 25 years, 19% (n=79) in the range 26-30 years, 29% (n=123) in the range 31-35 years, 22% (n=93) in the range 31-35 years, 14% (n=60) in the range 36-40 years, 8% (n=33) in the range 41-45 years and 5% (n=23) over 45 years. In terms of gender, 243 (56.9%) of the respondents were female and 184 (43.1%) were male. Considering the teaching area, 136 (31.9%) were from the “cultural area” (Languages, Philosophy, etc.), 81 (19.0%) from the “scientific area” (Mathematics, Physics, Economy, etc.) and 210 (49.2%) from the “technical area” (subjects for each specific professional area – e.g.: tourism, electronics, computer programming, business and administration, design, etc.). In terms of professional experience (number of teaching years) the mean was 8.0 (SD= 6.2).

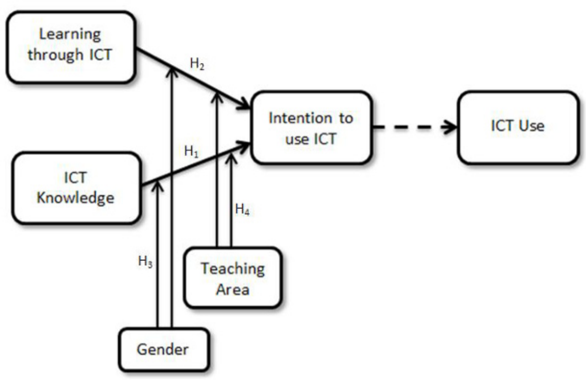

Figure 1. ISTTU model.

C. Instruments

The models presented before are widely studied and most of them already have questionnaires that enable its evaluation. However, none of these questionnaires were previously validated for Portuguese samples and different questionnaires have been developed to measure the same variables. For instance, the questionnaire presented by Birch & Irvine [2] had 23 items and targeted the pre-service teachers, whereas Teo’s questionnaire [54] only had 20 items and was directed to in-service teachers. We made some adjustments in a few questions to adapt the instrument to the audience and the results revealed significant differences when applied to pre-service teachers or in-service teachers.

However, theories are often not confirmed by empirical data. For instance, Birch & Irvine [2] applied the UTAUT model and concluded that “only effort expectancy was a significant predictor of teachers’ intentions to use ICT in their practicum teaching” (p.312). Furthermore, they determined that “UTAUT model has been very successful in the business sector” (p.311) but its application to teachers probably needs to integrate other variables such as “technology skill level”. The same is applied to the other models, mostly of them tested in pre-service teachers. However, as Birch & Irvine also pointed out [2], “in-service” teachers may have a better understanding of the demands, their students’ needs, technology and available resources. Teo [54] used the structural equation modeling technique to conclude that “Perceived Usefulness”, “Attitude Towards Use” and “Facilitating Conditions” were the variables with direct influence on Behavioral Intention to Use Technology, which is consistent with the relations described in TAM [13] and UTAUT [56] theories. Additionally, Teo concluded that "«Perceived Ease-of-Use» and «Subjective Norm» influence «Behavioral Intention to Use Technology» indirectly through «Attitude Towards Use» and «Perceived Usefulness», respectively" (p.2437) [54].

In our study we intended to measure if "Attitude Towards Technology" and "Technology Skill Level" are predictors of "Intention to Use Technology", using instruments already validated to Portuguese samples. We used: a) The questionnaire "Perceptions of Computers and the World Wide Web" developed by Liaw [52] to determine attitudes towards computers and the Internet; b) The Technological Knowledge section of TPACK Questionnaire, by Mishra & Koehler, [44]; and c) The "ICT use questionnaire", constructed by Luzio [3].

1) Attitude towards computers and Internet

The questionnaire "Perceptions of Computers and the World Wide Web" [52] was "formulated within the frames for assessing attitudes towards computers set out by these other instruments: Computer Attitude Measure (Kay, 1989, 1993), Computer Attitude Scale (Al-Khaldi & Al-Jabri, 1998; Loyd & Loyd, 1985; Nash & Moroz, 1997), and TAM (Davis, et al., 1989; Fenech, 1998; Lederer et al., 2000; Lin & Lu, 2000; Moon & Kim, 2001)" (p.20). Liaw's instrument was translated and validated on a Portuguese sample by Jorge & Miranda (2002) and applied by Luzio [3], Fernandes [50], Jorge [19] and Monteiro & Miranda [36] on other Portuguese samples. According to Jorge [19] "The questionnaire developed by Liaw, cited by more than one hundred other researchers and widely replicated, partially or integrally (Birgin, Çatlıoğlu, Gürbüz e Aydın, 2010, Fini, 2008, Teo, 2009, Yang & Lester, 2003) fits the purpose of simplicity and accuracy that all instruments must have" (p.88). As we intended to measure the attitude of teachers towards the Internet and computers, and this instrument was already validated to Portuguese samples, we considered it adjusted to our purpose. Liaw's original scales were scored on a 7 point Likert scale, but Jorge & Miranda [20] reduced it to a 6 point scale to avoid neutral answers.

This instrument, composed of two scales, each one with 16 items scored in a 6-point frequency rating scale that ranged from 1 (totally disagree) to 6 (totally agree) has been used to estimate teachers' attitudes towards computers and the World Wide Web (WWW). In our survey, these questions were presented in group 2, ranging from 201 to 216 (Computer Attitude Scale – 16 questions) and 217 to 232 (WWW Attitude Scale – 16 questions). For the Computer Attitude Scale, Cronbach's alpha reported by Jorge & Miranda [20] was 0.91 and the corrected item-total correlations ranged from 0.44 to 0.75. For the WWW Attitude Scale Cronbach's alpha was 0.93 and the corrected item-total correlations ranged from 0.47 to 0.80.

2) Technological Knowledge

The TPACK Questionnaire [44] integrates three sections: PK (Pedagogical Knowledge), TK (Technical Knowledge) and CK (Content Knowledge). Our sample is made of in-service teachers, most of them with significant professional experience (average=8.0 years, SD=6.2), so we assumed they already possess Pedagogical Knowledge and Content Knowledge. That is the reason why only the TK section was used in our survey in order to measure "Technological Knowledge" (TK). This section contained 6 questions scored in a 6-point Likert scale that ranges from 1 (totally disagree) to 6 (totally agree) to rate the extent to which participants agreed or disagreed with the statements. Profuse research with TPACK has reported Cronbach's alpha for TK, ranging from 0.84 to 0.93 [24]. In our survey, these questions were presented in group 3, numbered from 301 to 306 (6 questions).

3) ICT use

The "ICT Use Questionnaire" [3] has 25 questions scored on a 6-point Likert scale that ranges from 1 (never use) to 6 (always use). In our survey, these questions were presented in group 4, ranging from 401 to 425 (25 questions). The Cronbach's Alpha reported by Luzio for this scale was 0.935.

D. Procedure

In all the previously mentioned studies, the only psychometric property presented was Chronbach's Alpha. For that reason, we first conducted a preliminary analysis to evaluate the psychometric properties of data gathered with each scale of our multidimensional questionnaire: psychometric sensitivity (evaluated by Skewness and Kurtosis), factorial validity (assessed by an exploratory factor analysis – EFA), and reliability (measured by Cronbach's Alpha and Composite Reliability).

After carrying out a Confirmatory Factorial Analysis, we did not find any association of the 16 items in each scale with the three factors predicted by Liaw's theory: cognitive (related to beliefs), behavioral (related to use perceptions) and affective (related to pleasure associated with the use) [52] [17]. In fact, this questionnaire had revealed some problems in terms of psychometric validation of the constructs over time. The results typically reveal very good values for reliability (ranging from 0.90 to 0.94 in the initial study, and from 0.81 to 0.91 in our sample) but not for the psychometric validity. As Yang & Lester [5] observe, "Liaw's two scales for measuring attitudes towards computers and the Internet were found to be reliable but factorially complex" (p.649). It is also noteworthy that in the original study [52] only the Cronbach's alpha was reported and the other psychometric data properties were not available. If we associate to these problems the time that has passed since the publication of this scale (twelve years) and the technological development that occurred in the meantime, perhaps the use and the attitude towards computers and the Internet may have changed. The scale may, therefore, have to be adjusted, as the way people understand the questions may have slightly changed in the last decade.

1) Psychometric Sensitivity analysis

We first carried out a psychometric sensitivity analysis to determine any significant deviation from normality in the collected data. We analyzed Skewness and Kurtosis to identify potential asymmetries with the items. From the sensitivity analysis to Liaw's scale (Appendix A.2) we have determined that items 207, 209, 210, 211, 213, 214, 216, 218, 221, 224, 225, 226, 227, 231 and 232 revealed a strong deviation from normality with absolute values of skewness $|sk| \geq 3$ or kurtosis $|ku| \geq 10$ [46] [30]. Therefore, we decided to drop these items and, in this first phase, Liaw's questionnaire was reduced from 32 to 17 items.

From Luzio's scale related to the use of computers we carried out a similar procedure (Appendix A.3) and 2 items were dropped due to severe normality deviation (401 and 416) and Luzio's scale was reduced from 25 to 23 items.

No sensitivity issues were identified in "ICT Knowledge" scale construct (Appendix A.1) with all the 6 items from TPACK (used to estimate the ICT Knowledge) showing absolute values of skewness lower than 3 and kurtosis lower than 10. All items were kept in the analysis.

2) Exploratory Factor Analysis

Following these procedures, the initial multidimensional questionnaire, that congregates elements from three scales: Attitude towards computers and Internet [52], ICT use questionnaire [3] and Technological Knowledge [44], was reduced to 46 items (changed from 63 to 46 items).With this new survey we looked for the factors that emerged from the data analysis, conducting an Exploratory Factor Analysis (EFA), using the Principal Components Extraction, followed by a Varimax Rotation, using SPSS (v.19, IBM SPSS, Chicago, IL). The number of factors extracted was determined according to the Kaiser's Eigenvalue-greater-than-one rule. The adequacy of the items for factor analysis, determined by the Kaiser.Meyer-Olkin index, was very high (KMO=0.919).

E. Reliability

Reliability for each factor was retained and their respective indicators were first evaluated with Cronbach's Alpha; values above 0.7 would be enough to consider the instrument reliable [31] [22]. However, as Cronbach's Alpha evaluates factors with the same weight, other authors [6] consider that the reliability of the constructs should be evaluated with the Composite Reliability (CR). Typically, values of $CR \geqslant 0.7$ are considered to assure the instrument's reliability [30].

F. ISTTU Model

We used the Structural Equation Modeling technique to develop and test our ISTTU model. A two-step analysis was conducted [33] [21] using software AMOS (V.19, SPSS Inc, Chicago, IL): In the first step we evaluated and adjusted the overall fit of the factors present in the measurement model; In the second step, after we assured the quality of the model, we tested and adjusted the structural model, by evaluating its plausibility. The goodness of fit of the revised factors obtained in the EFA was evaluated, as well as the invariance of the measurement model and the structural model ISTTU in a sample of teachers from the vocational stream of vocational schools in Portugal.

The significance of the regression and measurement coefficients was evaluated after an estimation of the parameters using the Maximum Likelihood (ML) method.

The overall goodness of fit of the factorial model was evaluated according to the most used fit indexes compared against their reference values: $\chi2/df<4$, CFI, GFI and TLI>0.9 and RMSEA<0.05 [29] [23]. The model was further refined by adjusting the Modification Indexes (MI>11; $p<0.001$) and the local goodness of fit was determined by items individual reliability.

Multivariate normality was assessed by removing items that revealed values of Skewness and Kurtosis not adequate to the usage of the Maximum Likelihood method [46]. The model was tested with and without the outliers and we opted to eliminate outliers from the sample.

The structural coefficient significance was determined by a Z-test, produced from the Amos Software (Critical Ratio and p-value), being considered statistically significant with p-value $\leqslant 0.05$. The model coefficient estimates are presented in their standardized form.

III. RESULTS

A. Factorial structure and reliability of the scales

In Appendix B.1 we present the three factors extracted from the "Attitude Questionnaire" and the items factor weights. The three extracted factors explained 70.3% of the total variance and were defined as follows: Factor 1 – "Confidence Towards Computers and Internet" (items 201, 202, 203, 204, 205, 217, 219, 221), Factor 2 - "Learning Through ICT" (items 208, 215, 228, 229, 230) and Factor 3 – "Interaction using ICT" (items 206, 222).

When analyzing the factors from the "Use Scale" and considering the items kept in the model after the sensitivity analysis, we proceeded to the exploratory factorial analysis (KMO=0.896). The factor weights of the four components extracted are presented in Appendix B.2. We concluded that items were organized according to four factors that explain 63.4% of the total variance: Factor 1 - "Interaction" (items 419, 420, 421, 422, 423, 424, 425), Factor 2 - "Search for Information" (items 404, 405, 406, 407, 408), Factor 3 – "Resource Production" (items 402, 410, 411, 412, 413, 414) and Factor 4 – "Interaction" (items 417, 418).

Regarding reliability, all the retained factors presented revealed "acceptable" or "good" internal consistency as evaluated by Cronbach's α greater than 0.7 [22] [40] [31]. The Cronbach's α for the factors identified is presented in Table I.

TABLE I. CRONBACH'S ALPHA FOR THE FACTORS IDENTIFIED.

Scale	Factor	α
Attitude	Confidence	0.930
	Learning through ICT	0.881
	Interaction over ICT	0.894
Use	Interaction	0.928
	Search for information	0.876
	Resource Production	0.829
	Interaction	0.725
TK	ICT Knowledge	0.945

Subscales "ICT knowledge", "Learning through ICT" and "Intention to use ICT" were used in the ISTTU model. The values of CR and AVE for these subscales are shown in Table II:

TABLE II. CONSISTENCY.

Factor	CR	AVE
ICT Knowledge	0.80	0.73
Learning through ICT	0.75	0.72
Intention to use ICT	0.85	0.65

Typically, values of $CR \geqslant 0.7$ are considered to be good indicators for reliability and values of AVE⩾0.5 are considered to indicate convergent validity for the factors [29] [23]. Therefore, from Table II, we can consider the instruments reliable and with convergent validity for all three factors.

B. ISTTU model

The fitted research model is presented in figure 2, with the standardized regression coefficients and R^2 for the ISTTU model ($\chi2(32)=59.407$; $\chi2/df=1.856$, CFI=0.990, GFI=0.973, TLI=0.986 and RMSEA=0.045, P(rmsea≤0.05)=0.663).

The measurement model for the latent variables revealed a good quality of fit. The structural model explained 45% of the total variability of the variable "Intention to use ICT" ($p<.001$). The highest effect of "ICT knowledge" was observed on "Intention to use ICT" (BInt.ICTK=0.751; SE=0.072; $\beta=.63$; $p<.001$). The trajectory "Learning through ICT → Intention to use ICT" was not significant (BInt.Learn=0.211; SE=0.101; $\beta=.10$; $p=.037$). The model also showed a moderate correlation between "ICT knowledge" and "Learning through ICT" ($r=0.35$; $p<0.001$).

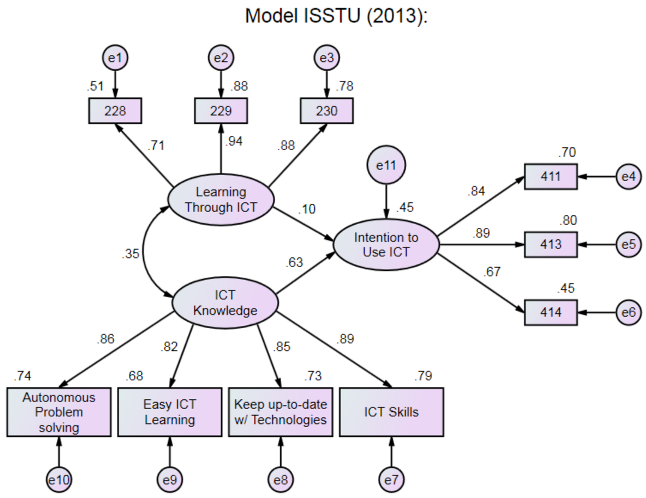

Figure 2. Structural Model ISTTU-standardized estimates

C. Socio demographic effects over Intention to Use ICT

We further analyzed the trajectory "ICT knowledge" to "Intention to use ICT", considering variables "Gender" and "Teaching Area". The variable "Teaching Area" categorizes teachers according to three main areas: "cultural", "scientific" and "technical".

TABLE III. STANDARDIZED STRUCTURAL WEIGHTS IN THE ISTTU MODEL (β) AND VARIABILITY EXPLAINED PER TEACHING AREA. P-VALUES ARE FOR THE PAIRWISE "TEACHING AREAS" β'S COMPARISONS.

Teaching Area	β	R^2	p		
			Cultural area	Scientific area	Technical area
Intention to use ICT <- Learning trough ICT					
Social and Cultural area	0.09	0.28	----	----	----
Scientific area	0.16	0.18	0.347	----	----
Technical area	0.04	0.51	0.464	0.584	----
Intention to use ICT<- ICT knowledge					
Social and Cultural area	0.49	0.28	----	----	----
Scientific area	0.37	0.18	0.790	----	----
Technical area	0.70	0.51	<0.001	<0.001	----

There were no significant differences in the model fit to the two gender groups ($\Delta\chi^2$ (7)=11.569, p=0.116). On the contrary, the model was not structurally invariant between "Teaching Area" ($\Delta\chi^2(14) = 40.433$: $p<0.001$). The different structural weights per teaching areas are shown in Table III. In this table, we also present a p-value analysis for the comparison between teaching areas.

The standardized weight of "ICT knowledge" to "Intention to use ICT" was significantly larger in the "Technical Area" as compared to the other two teaching areas ($p<0.05$). The differences, when evaluating the trajectory in pairwise comparisons in the different teaching areas, are not significant in the trajectory "Learning through ICT" to "Intention to use ICT".

D. Discussion

Applying a structural model to predict "Intention to Use ICT" from "Learning through ICT" and "ICT Knowledge" from constructs previously validated in a sample of 427 teachers of professional schools in Portugal, we confirmed (H1) "ICT Knowledge" has a strong effect on the "Intention to Use ICT". However, we did not confirm (H2)-"Learning through ICT" has a strong effect on the "Intention to Use ICT". These results suggest that online training may have the same impact on people as traditional face-to-face modalities. This probably means that, nowadays, people naturally integrate technology in their daily activities so that "learning through technology" (in a virtual learning environment) may be as easily accepted as a face-to-face classroom experience. However, the fact that the trajectory "Learning through ICT → Intention to use ICT" was not significant means that, in this model, the "Intention to Use ICT" should not be affected by the way people learn.

In this study, we did not confirm H3 and we may conclude that "Gender" does not affect the way ISTTU model performs. In previous research it was clear that men had a better attitude towards digital technologies than women [16] [4]. Others concluded that the differences were not consistent [25]. Perhaps in the last decade the differences were dimmed as digital technologies, particularly the Internet, evolved towards strands that are more appealing to women (e.g.: communication, conversation and social interaction).

We did confirm H4 and we conclude that "teaching area" affects the influence of "ICT Knowledge" on the "Intention to Use ICT". The impact of "ICT knowledge" on the "Intention to Use ICT" is stronger when teachers come from technical areas when compared with other teaching areas, although the differences in this trajectory are not statistically significant between the groups. In previous research, familiarity and experience with computers allowed to foresee a stronger attitude towards the use of digital technologies [47] and future learning experiences with computers [43]. A study developed by Silva [14] with a representative sample of pre-service teachers from Universities in Portugal revealed that teachers from the "Humanities" area declared the lowest level of contact and training with technologies (51.5% of them declared not having any contact with technologies whatsoever) as teachers from the "Sciences" area declared to have the highest contact with technology.

In our sample, teachers from the technical area revealed the better attitude and intention to use technology. Perhaps their bindings to companies and real-world problems have fostered their need to use digital technologies and its integration in classroom situations. Additionally, the practical nature of the "professional courses" may also impose the use of technologies to prepare students for the labor market. What was somewhat surprising was the low use and attitude towards technology from teachers of the scientific area. Although they probably have had contact with technologies, they may perceive their main role as to prepare young people with skills associated with abstract thinking, where technology can even be seen as harmful.

1) Limitations of the study

Due to the choice of an online platform to implement the questionnaire, we must consider the possibility that only teachers with a positive attitude have chosen to respond and we may have contributed to the exclusion of teachers from the process of integrating technologies in their practices. However, the geographical dispersion and the large number of teachers of the population dissuaded us to collect data using the pen and paper method alongside with online data collection. Another limitation was the variance explained by this model (R^2=0.45), meaning that 55% of the reasons that foster the use of technology are still unaccounted for. Perhaps the integration of other variables presented in the TAM model, such as "effort expectancy" [2] or "self-esteem" or "computer anxiety" [54] can contribute to refine the ISTTU model.

E. Conclusion and future research

The findings of this study suggest that the "Technical Knowledge" of teachers has a strong influence on "Intention to Use ICT". We may infer that fostering the development of ICT skills on teachers (increasing "ICT Knowledge") will develop the "Intention to Use ICT". According to Venkatesh et al. [56], "Intention to Use ICT" is the strongest predictor of "ICT use". We may therefore conclude that the increase of teachers' "ICT knowledge" can trigger the use of technology in their activities.

The results also suggest that without a strong component in terms of "ICT Knowledge" we should not expect teachers to use ICT in their professional activities. That is the reason why we should first provide training to achieve ICT skills and then expect teachers to use it proficiently. Like in many other circumstances in life, we should not expect people to use tools if we do not teach them how they can be used.

Further research based on field experience is needed to confirm these findings, by integrating in this model other constructs, such as: Effort Expectancy, Computer Anxiety, Perceived Usefulness, Perceived Ease-of-Use, aiming to increase the variance explained by the proposed model.

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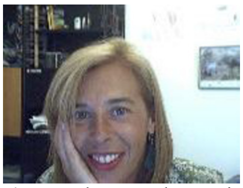
AUTHORS' PROFILE



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APPENDIX A – SENSITIVITY ANALYSIS (SK & KU)

Appendix A.1 - Sensitivity analysis (Sk & Ku) for "ICT Knowledge"

Question	Mean	Std. Dev.	Sk	Ku
301. I know how to solve my own technical problems	4.48	1.345	-0.442	-0.798
302. I can learn technology easily	5.24	0.916	-1.098	0.588
303. I keep up with important new technologies	4.42	1.294	-0.445	-0.666
304. I frequently play around with technology	4.83	1.208	-0.690	-0.582
305. I know about a lot of different technologies	4.79	1.252	-0.861	-0.030
306. I have the technical skills I need to use technology	4.87	1.172	-0.749	-0.473

Appendix A.2. - Sensitivity analysis for the "Attitude" Liaw's questionnaire

Question	Mean	Std. Dev.	Sk	Ku
201. I feel confident using a computer	5.54	0.853	-1.966	3.618
202. I feel confident using data storage devices (floppy disks, pen-drives, CDs)	5.65	0.768	-2.566	7.035
203. I feel confident using a text processor (Word, other)	5.67	0.707	-2.539	7.577
204. I feel confident acquiring new computer ICT skills	5.51	0.846	-1.854	3.365
205. I like to use computers	5.61	0.759	-2.333	6.374
206. I like to talk about computers	4.29	1.556	-0.468	-0.877
207. I have (or would like to have) a computer at home	5.94	0.419	-9.431	99.054
208. The computer facilitates my daily activities	5.87	0.470	-5.053	34.660
209. Computers are necessary in my professional life	5.94	0.304	-7.193	72.658
210. Computers are useful tools	5.92	0.360	-7.695	86.189
211. In my daily activities I use computers for several purposes (text processing, email, internet surfing, etc)	5.93	0.339	-8.751	108.814
212. I can improve my professional performance by increasing my computer usage	5.35	1.156	-2.181	4.616
213. Computer usage is useful in my profession	5.88	0.393	-4.335	27.024
214. Computer usage can improve my chances of finding and keeping a job	5.69	0.712	-3.342	14.991
215. Computers can be excellent learning tools	5.78	0.527	-2.992	11.222
216. It is useful to know how to use computers	5.90	0.369	-5.112	36.187
217. I feel confident using the Internet/World Wide Web (WWW)	5.67	0.658	-2.359	6.186
218. I feel confident using E-mail	5.73	0.643	-3.147	12.683
219. I feel confident using WWW browsers (e.g. Internet Explorer, Netscape Communicator)	5.52	0.886	-2.038	3.772
220. I feel confident using search engines (e.g. Yahoo, Excite, and Lycos)	5.65	0.700	-2.526	8.098
221. I like to use E-mail to communicate with others	5.72	0.627	-3.047	12.661
222. I enjoy talking with others about the Internet	4.53	1.476	-0.746	-0.431
223. I like to work with the Internet/WWW	5.54	0.814	-1.981	4.022
224. I like to use the Internet from home	5.76	0.642	-3.691	16.903
225. I believe using the Internet/WWW is worthwhile	5.88	0.427	-5.419	44.384
226. The Internet/WWW helps me to find information	5.86	0.455	-4.748	34.310
227. I believe the Internet makes communication easier	5.70	0.677	-2.931	10.891
228. The multimedia environment of WWW (e.g. text, image) is helpful to understand online information	5.62	0.700	-2.254	6.797
229. I believe the Internet/WWW has potential as a learning tool	5.67	0.659	-2.429	7.972
230. I believe that the Internet/WWW is able to offer online learning activities	5.67	0.675	-2.577	8.735
231. I believe that learning how to use the Internet/WWW is worthwhile	5.79	0.577	-3.794	19.272
232. Learning Internet/WWW skills can enhance my academic performance	5.59	0.854	-2.999	10.774

Appendix A.3 - Sensitivity analysis (Sk & Ku) for the "Use" Luzio's Scale

Question	Mean	Std. Dev.	Sk	Ku
401. I use ICT to prepare tests and worksheets for my classes	5.81	0.545	-4.206	23.846
402. I use ICT to develop presentations for my classes (ex. Powerpoint)	5.29	1.024	-1.495	1.875
403. I use ICT to prepare handout texts to support my classes	5.57	0.800	-2.317	6.716
404. I use ICT to search the Internet for subjects for my classes	5.56	0.708	-1.632	2.543
405. I use ICT to search for bibliography	5.32	0.928	-1.507	2.314
406. I use ICT to search for non-bibliographic databases	5.19	1.042	-1.305	1.305
407. I use ICT to research scientific contents in my professional area	5.49	0.707	-1.274	1.078
408. I use ICT to research other issues that can increase my knowledge	5.52	0.732	-1.833	4.533
409. I use ICT to produce schemes (transparencies, etc.)	4.61	1.728	-1.013	-0.357
410. I use ICT to produce photographs	4.48	1.612	-0.753	-0.645
411. I use ICT to produce webpages	3.52	2.058	-0.005	-1.649
412. I use ICT in spreadsheet applications (Excel or other)	5.20	1.247	-1.667	2.044
413. I use ICT to develop applications over databases (Access or other)	3.64	2.030	-0.079	-1.631
414. I use ICT in applications for data processing (SPSS or other)	3.27	1.989	0.194	-1.561
415. I use ICT applications to scan and compose images (scanner or other)	5.28	1.129	-1.757	2.526
416. I use ICT in word processing applications (word, publisher or other)	5.75	0.595	-3.013	11.183
417. I use ICT to interact with colleagues (teachers at my school) via e-mail	5.58	0.816	-2.508	7.456
418. I use ICT to interact with students through e-mail, for tutoring activities	5.27	1.098	-1.731	2.764
419. I use ICT to interact with teachers from other schools via e-mail	4.59	1.692	-0.925	-0.528
420. I use ICT to interact with students in forums	3.27	1.901	0.161	-1.468
421. I use ICT to interact with my colleagues in forums	3.24	1.872	0.154	-1.434
422. I use ICT to interact with teachers from other schools in forums	2.98	1.843	0.399	-1.253
423. I use ICT for synchronous interaction with my students (E.g.: Messenger)	3.45	1.928	0.048	-1.515
424. I use ICT for synchronous interaction with my colleagues (E.g.: Messenger)	3.77	1.894	-0.235	-1.431
425. I use ICT for synchronous interaction with teachers from other schools	3.15	1.906	0.272	-1.415

APPENDIX B - PRINCIPAL COMPONENT EXTRACTION

Appendix B.1 - Principal Component Extraction for "Attitude" Liaw's questionnaire.

Question	Component			h^2
	1	2	3	
201. I feel confident using a computer	0.883			0.824
202. I feel confident using data storage devices (floppy disks, pen-drives, CDs)	0.881			0.823
203. I feel confident using a text processor (Word, other)	0.823			0.714
204. I feel confident acquiring new computer ICT skills	0.805			0.744
205. I like to use computers	0.629			0.640
206. I like to talk about computers			0.818	0.823
208. The computer facilitates my daily activities		0.666		0.527
212. I can improve my professional performance by increasing my computer usage				0.245
215. Computers can be excellent learning tools		0.804		0.695
217. I feel confident using the Internet/World Wide Web (WWW)	0.828			0.739
219. I feel confident using WWW browsers (e.g. Internet Explorer, Netscape Communicator)	0.809			0.708
220. I feel confident using search engines (e.g. Yahoo, Excite, and Lycos)	0.829			0.753
222. I enjoy talking with others about the Internet			0.857	0.860
223. I like to work with the Internet/WWW	0.440	0.472	0.468	0.636
228. The multimedia environment of WWW (e.g. text, image) is helpful to understand online information		0.736		0.653
229. I believe the Internet/WWW has potential as a learning tool		0.869		0.807
230. I believe that the Internet/WWW is able to offer online learning activities		0.829		0.759
% variance explained	49.1%	13.7%	7.5%	
Total Variance Explained	70.3%			

Rotated Component Matrix (Rotation converged in 5 iterations).

Appendix B.2 - Principal Component Extraction for Luzio's "Use" scale

Question	Component				h^2
	1	2	3	4	
402. I use ICT to develop presentations for my classes (ex. Powerpoint)			0.522		0.464
403. I use ICT to prepare handout texts to support my classes		0.442			0.402
404. I use ICT to search the Internet for subjects for my classes		0.786			0.692
405. I use ICT to search for bibliography		0.781			0.680
406. I use ICT to search for non-bibliographic databases		0.741			0.650
407. I use ICT to research scientific contents in my professional area		0.827			0.750
408. I use ICT to research other issues that can increase my knowledge		0.754			0.679
409. I use ICT to produce schemes (transparencies, etc.)					0.236
410. I use ICT to produce photographs			0.601		0.571
411. I use ICT to produce webpages	0.422		0.677		0.682
412. I use ICT in spreadsheet applications (Excel or other)			0.646		0.519
413. I use ICT to develop applications over databases (Access or other)			0.744		0.733
414. I use ICT in applications for data processing (SPSS or other)			0.696		0.608
415. I use ICT applications to scan and compose images (scanner or other)			0.517	0.568	0.622
417. I use ICT to interact with colleagues (teachers at my school) via e-mail				0.757	0.686
418. I use ICT to interact with students through e-mail, for tutoring activities		0.401		0.552	0.601
419. I use ICT to interact with teachers from other schools via e-mail	0.570			0.402	0.520
420. I use ICT to interact with students in forums	0.837				0.770
421. I use ICT to interact with my colleagues in forums	0.868				0.813
422. I use ICT to interact with teachers from other schools in forums	0.855				0.807
423. I use ICT for synchronous interaction with my students (E.g.: Messenger)	0.797				0.702
424. I use ICT for synchronous interaction with my colleagues (E.g.: Messenger)	0.760				0.662
425. I use ICT for synchronous interaction with teachers from other schools (E.g.: Messenger)	0.828				0.737
% Variance Explained	38.7%	12.3%	7.3%	5.2%	
Total Variance Explained	63.5%				

Rotated Component Matrix (Rotation converged in 5 iterations).