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of bachelor students?**

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Abstract

Can Openness to ICT and Scientific Research Predict the ICT Skills and ICT use of Bachelor's Students?

In this article, we focus on the question of why some bachelor's students have more proficiency in ICT skills and use computers and the Internet more frequently than other students do. To answer this question, we rely on the core variables of the TAM (Technology Acceptance Model), on the orientation of students toward scientific research, and on contextual factors. TAM has been applied successfully in research before, but in this article, the model is expanded with variables regarding the orientation of students toward scientific research, and is geared towards the relationship to basic ICT skills and the sustained use of these skills. In order to attain a more reliable instrument to measure proficiency in ICT skills and the frequency of ICT use, several new instruments are constructed. The results show that this model, a combination of four basic TAM variables, together with the identity commitment of students focused on the appreciation of scientific research and some context variables, can explain a substantial proportion of the variance in different ICT skills, but considerably less of the frequency of ICT use.

Keywords

Pedagogical issues
Post-secondary education
Media in Education
Computer-mediated communication
Country-specific developments

Can Openness to ICT and Scientific Research Predict the ICT Skills and ICT use of Bachelor's Students?

1. Introduction

The majority of contemporary university students belong to the group that has been called 'the Net Generation', 'digital natives', or 'millennium students'. Although these labels do not always refer to the same group of people and disagreement exists as to the exact meaning of these concepts (Jones, Ramanau, Cross, & Healing, 2010), it is clear that these youngsters frequently and intensely work with computers, mobile devices, and the Internet. They are also assumed to have experience with a broad range of software tools and applications – in popular terminology often called 'apps' on mobile devices. Referring to research from the USA, the UK, and South Africa, Jones et al. (2010) noted that digital natives may have very different levels of command of ICT (Information and communication technology) instruments and programs. They frequently stick to word processing or browsing the Internet, not uncommonly with a focus on SNS (Social Networking Services), but they are not particularly skilled when it comes to less popular ICT skills, instruments, or programs. Similar observations have been made in our own research projects among university freshers, conducted in 2004, 2005, and 2009. We also observed that students with more ICT experience did not show increased levels of expertise with all types of ICT skills. Although computers and the Internet were already frequently used before 2004, the importance of ICT has grown explosively since then. There has been a tremendous growth in the popularity of SNS (Anonymous 1), the use of virtual learning environments at universities has surged, university libraries have made searchable databases available to students and researchers, notebooks and tablets have been introduced, etc. These changes have brought ICT closer to students than ever before. Although these evolutions were expected to make large fractions of students increasingly familiar with ICT, empirical research has shown that while some basic ICT skills have improved over time, others have remained stable, and others have even declined (Anonymous 2).

Before presenting the aims of our research, we shed some light on the concept of 'ICT'. In the information society or network society in which we now live, this concept has been given many definitions. The OECD (Organisation for Economic Co-operation and Development), for example, stressed the role of ICT products: "ICT products must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display." (OECD, 2011, p. 20). This takes place by passing information and communications along the nodes of many networks to different people in society through various communication instruments. By storing and transmitting the

communications and information through different nodes, services are delivered to people and/or machines (ITU, 2012). Using this as the starting point to define the subject matter for our research would take us too far. In this article we do not aim to study the services provided by all ICT products, but instead confine our analyses to the basic ICT skills that students need in order to function properly in the network society and to the level of acceptance of some ICT instruments and procedures in daily life. It is clear that the advancement of information technologies anticipates different skills at the different stages of development. For example, in 1999 an American agency mentioned the following ICT skills as being basic for a participant in modern society: “(1) setting up a personal computer; (2) using basic operating system features; (3) using a word processor to create a text document; (4) using a graphics and/or artwork package to create illustrations, slides, or other image-based expressions of ideas; (5) connecting a computer to a network; (6) using the Internet to find information and resources; (7) using a computer to communicate with others; (8) using a spreadsheet to model simple processes or financial tables; (9) using a database system to set up and access useful information; and (10) using instructional materials to learn how to use new applications or features.” (NRC (National Research Council) [1999] cited in Kaminsky, Switzer, & Gloeckner, 2009). These remain very useful skills, but some could be added to this list. Today it would be very helpful for people to be able to use a smart phone or a tablet computer properly, or work with VoIP. It is clear that depending on the development of ICT and the specific development of ICT in a particular profession or a particular society, these demands might change.

More than three years after our last survey, we wanted to obtain a more detailed view of ICT use by students, not only with regard to the basic skills that remain necessary as a solid foundation for knowledgeable ICT use, but also to include the use of new ICT instruments and technologies – which are very popular but do not require many new skills to work with – and more advanced ICT skills. Therefore, the measurement instrument that we used in our earlier research (Anonymous 3; Anonymous 2) was updated, to take account of the strong development of ICT and the associated ICT skills over the course of recent years, and to be able to measure more diverse ICT skills than was possible in earlier research.

A more detailed view of ICT skills and ICT use can then form the basis for answering the question of why some students have more knowledge of ICT skills and why they use some functions of computers and the Internet more than other students do. In this article, we analyze two possible answers: openness to ICT and openness to scientific research.

Access to computers and the Internet are without doubt important for the learning process. However, the learning process is also influenced by the students’ motives with regard to ICT. In this regard, the belief that using ICT might help students to study and/or complete course work is important. Another element is the capacity of students to use ICT with ease. If the use of ICT creates more problems than it solves (or is

perceived that way), students will not be eager to apply ICT skills. In addition, a student who feels some anxiety while working with ICT will not be motivated to carry on doing this. These variables have been used in much research and are included in the Technology Acceptance Model (TAM) to explain the acceptance of new technologies, but these variables can also be used to explain the continued use of ICT, as we do in this article.

In spite of the strength of the TAM variables in explaining the use of technology, the approach can still be improved by taking into account other variables. In this article, we look into the possible effect of a student's openness toward scientific research. We carried out our study in a research-intensive university, where the intended learning outcomes for the students explicitly include understanding and conducting scientific research. Students are trained to become researchers. In their daily classes, they are presented with research, they meet researchers, read their work, and enter into discussions with them. They also learn and experience that researchers use computers and the Internet, for example in order to carry out different types of calculations and to study databases. Nowadays, this is not only true for researchers in the natural sciences, but also for historians and philosophers – in fact, for all research domains. Nevertheless, students' preferences for using ICT may not only be inspired by experienced researchers' frequent use of ICT, but may also stem from the structural similarities between ICT and scientific research. ICT skills as part of information systems can be used to collect information, to store this information, to distribute it, to retrieve it, and to analyze it. All these tasks also are part and parcel of conducting scientific research. This too may bring about a better mastering of ICT skills and more frequent use of the computer, the Internet, ICT instruments, and ICT programs.

In the next section, we describe the theoretical foundations for both the TAM variables and openness to research in relation to the ICT use of students. Then we explain the research methodology of the survey we conducted among university bachelor's students, followed by a presentation of the results. Next, we discuss these results, and in a final section we draw some conclusions with regard to the effects on ICT use of openness to ICT and openness to scientific research.

2. Theory

2.1. Technology acceptance model

For more than twenty years, the technology acceptance model (TAM) developed by F. Davis (1989) and Davis, Bagozzi, and Warshaw (1992) has had a tremendous influence on the study of the acceptance of new technologies. Many researchers have added to the model, and one of the most promising improvements was designed by Venkatesh, Morris, Davis and Davis (2003). They termed this 'the unified

theory of acceptance and use of technology' (UTAUT). N. Oye, A. Iahad, and Ab. Rahim (2012) contend that this theory can explain 70% of the variance of the dependent variable, whereas TAM cannot explain more than 40%. In spite of this positive evaluation of UTAUT by Oye et al. (2012), when they applied the four most important variables of UTAUT to predict the ICT acceptance of 100 Nigerian academics, they did not find higher proportions than 27% and some variables did not play a role at all. This comes as no great surprise, because whether TAM or UTAUT can better explain the acceptance of new technologies depends on the level of acceptance of new technologies at the time of observation, the need for this technology, the culture of the group (Nistor, Lerche, Weinberger, Ceobanu, & Heymann, 2012), and the openness to the technology among the significant others of the group under research.

We do not intend to describe the development of TAM, UTAUT, and related theories. In earlier publications, we presented some short overviews (Anonymous 3, Anonymous 2), and other sources that provide information about these models are numerous (see for example: Lee, 2008; Chatzoglou, Sarigiannidis, Vraimaki, & Diamantidis, 2009; Tao, Cheng, & Sun, 2009; Teo, Lee, Chai, & Wong, 2009; Liu, Chen, Sun, Wible, & Kuo, 2010; Nair & Das, 2011; Oye et al., 2012; Ghazizadeh, Lee, & Ng Boyle, 2012). In this article, we confine our presentation to the key concepts of TAM and to the extended model we termed TAM+ in an earlier publication (Anonymous 2). We adapt this model specifically to examine the extent to which the scientific research orientation of students might contribute to the explanation of their ICT skills and the frequency of their ICT use. It is obvious that most university students nowadays have already worked with a computer before attending university and that a large number of them are familiar with many programs and Internet procedures. Nevertheless, in our view the key concepts of TAM allow us not only to explain the acceptance of new technologies, but also the basic ICT skills and ICT use of university students.

Davis (1989; Davis et al., 1992) provided an important explanatory model for the acceptance of modern technology, applying the variables *perceived usefulness* and *perceived ease of use of the technology*. The first variable also has been labeled 'usefulness of the technology' or 'performance expectancy' (Venkatesh et al., 2003). The second variable has also been represented by the concepts 'control of the technology', 'effort expectancy', and 'computer self-efficacy' (Venkatesh et al., 2003; Chatzoglou et al., 2009; Lai, Wang, & Lei, 2012). The first variable refers to the perception of a user that the technology has a particular level of convenience for performing the work at hand. The second refers to the perception of the difficulty of learning to use a particular technology. The hypothesis underlying TAM is that a person will be interested in learning to work with a computer and the Internet and also will be particularly inclined to work with these instruments if he or she has a positive idea about the support resulting from working with

a computer and the Internet, and about the relative ease of learning how to work with a computer and the Internet.

The TAM variables are important conditions, as has been frequently shown in research (Arenas-Gaitán, Ramírez-Correa, & Rondán-Cataluña, 2011), but these conditions do not offer a full explanation of the level of working with a computer or the Internet. The UTAUT model includes some additional factors that might contribute to the explanation of the acceptance and mastering of a new technology, i.e. *social influence* and *facilitating conditions* (Venkatesh et al., 2003). ‘Social influence’ refers to the opinion of participants that a substantial group of people support the use of the technology. ‘Facilitating conditions’ refers to the opinion of participants that there is technical support available for using the new technology. In the model that we present below, we merge these two variables into one. We use ‘facilitating conditions’ when students have followed an ICT course in secondary school and/or at university and can count on support. The UTAUT model includes three additional variables that have an indirect influence on the acceptance of a technology: *self-efficacy*, *anxiety*, and *attitude*. ‘Self-efficacy’ in fact overlaps with the ‘perceived ease of use’ of the TAM model. ‘Anxiety’ refers to the level of feelings of fear people have about using a technology. From our research on students up to 2009, it appears that anxiety about ICT predicts lower ICT use and mastering of ICT skills (Anonymous 2), a finding confirmed by Jahromi, Lavasani, Rastegar, and Mooghali (2010), Mazloumiyan, Akbari, Rastegar, and Jahromi (2011), Huffman and Huffman (2012), Celik and Yesilyurt (2012), and Nistor et al. (2012). ‘Attitude’ refers to the overall affective reaction of a person to using a technology.

2.2. Social context

In addition to the variables included in these models, any theoretical framework on technology use needs to take into account the social context in which people operate. The acceptance and/or application of a technology depends not only on the individual expectations of individuals, but also on the *social context* in which a technology is learned or applied. For example, it is not difficult to imagine that university students are more eager to learn and more capable of learning and applying ICT applications than a retired manual worker who never needed to use any ICT applications. In our model, five contextual variables are included: gender, the educational status of the parents, the domain of study of the student, participation in an ICT course in secondary school, and participation in an ICT course at university. Gender is typically a strong explanatory variable for differences in ICT use. Although the differences between males and females may have diminished over time, they cannot be disregarded. Second, the educational background of the parents is included, both because it is an important determinant of the occupation of the parents and because it can serve as an indicator of the economic and cultural position of the parents and their children. Third, the domain of study (science vs. humanities) is included in the model because ICT might be used or

approached differently in the humanities than in the sciences. Fourth, students who attended an ICT course in secondary school might be better trained for ICT skills when arriving at university. Fifth, attending a course at the university where a computer is used by the students might create more opportunities for them to practice their ICT skills. With these five variables referring to the social context, we try to capture the students' viewpoint, from which they give meaning to their world. Van Dijk and Hacker (2003) located the viewpoint of an actor in the social context within a process of social differentiation, a process in which actors interpret and use ICT. In line with their argument, we do not start from a view that there are clear-cut and fixed differences between those who understand ICT and those who do not – in other words that there is a clear digital divide. Instead, we contend that the social context must be taken into account, because it leads to digital differentiation: to situational differences where some individuals will be able to obtain more information about ICT, whereas others will have less opportunities to grasp its functioning, resulting in differentiated, but not preconditioned, ICT use depending on the social context.

Starting from TAM and the additional variables described above, we want to focus on the acceptance and the daily use of *basic* ICT knowledge and skills. The usefulness of TAM in explaining ICT use has been shown in a large body of research (for an overview, see Anonymous 3), but most researchers are interested in the acceptance of ICT in its different forms (e.g. web-based learning, new teaching technology, etc.) and only a few have paid attention to the acceptance or the daily use of the Internet and/or a computer (for example, Ekizoglu, Tezer, & Bozer, 2010; Huffman & Huffman, 2012). In recent years, studies on ICT use in higher education have tended to assume that because students grew up with computers, they know all the basics; an assumption we do not readily share. Instead, we want to ask the question: do students know the basics of ICT use?

2.3. ICT as an analogy for Science Research

In addition to our focus on TAM for explaining the acceptance and mastery of basic ICT skills and the use of some basic ICT applications by university students, we also hypothesized that the orientation of students toward science could offer an additional explanation for the mastering of ICT skills and the application of ICT skills. Why did we make this assumption? One of the main purposes of a university education is to learn about, and learn to carry out, scientific research. When students are taught scientific research, they learn about its characteristics, which show some resemblance to the characteristics of ICT or information systems in general. It is therefore not unlikely that students who are strongly interested in scientific research also will be more interested in mastering ICT skills and the use of ICT.

What are the characteristics of information systems? Laudon and Laudon (2004: 8) defined an information system as: “a set of interrelated components that collect (or retrieve), process, store, and distribute

information to support decision making and control in an organization.” These basic functions are all present in information technology. An information worker needs instruments to capture the information (input) that is then processed. If information cannot be captured, the system cannot function. The instruments to capture information can include a keyboard, a scanner, a camera, a tape recorder, etc. Once the information is captured, it can be transferred (processed) within the system. The information can be sent to another device (distribution), for instance another computer in a network. The information can also be stored somewhere (e.g. on a hard disk or a USB stick) in order to be used in a subsequent phase of the information flow. An information system also needs instruments to retrieve the stored information. For the functioning of a computer, for example, the operating system (e.g. Microsoft Windows or Mac OS X) is paramount for organizing and retrieving the necessary information. The operating system is also instrumental in the elaboration of the information. It can create new information, reorganize the old information, or recalculate what was delivered in the first step (processing). The new or reorganized information can then again be distributed and made available, to the system itself (for instance in the RAM) or to a person working within an information system (for instance on a display device or as an audible message).

Looking at the procedures of scientific research, they show marked similarities to the characteristics of an information system (collection, processing, storage, and distribution). Of course, we do not mean to suggest that scientific research is a closed system that only functions by means of what is immediately provided to the researcher. On the contrary, it is a researcher’s calling to look for new information and new connections between information in order to arrive at new insights and a better understanding of the facts. A researcher starts with questions about how reality is composed, why it is composed as it is, and why it functions as it does. He or she will then decide on the most important factors that can elucidate the reality under investigation. Instruments are needed in order to capture this reality. Although all researchers rely mainly on observations by eye and ear, and although there are many differences between the instruments used to observe the world of nature and the social world, it is important for all these instruments to be reliable and to produce valid information. In order to be able to assess the reliability and validity of the information, there should be a transmission of what has been captured. The transmission of information presupposes a vocabulary or symbols that deliver the correct picture of what has been captured during the research process, which can be stored in reports, on the hard disks of a computer, on audio tapes, etc. In this way, not only the individual researcher but the whole research community can get a clear picture of the observations, can assess their reliability and validity, and can introduce solutions if and when these criteria are not met. Although storage is very important, it is not enough for the progress of scientific research. It must be possible to retrieve easily and quickly what has been collected, a function fulfilled by large databases available to the scientific community, in which most scientific observations are

stored. This makes it possible for researchers to come relatively close to all that is known about a particular phenomenon, possibly apart from the newest developments that are still under investigation in research units. However, data per se is not taken for granted by researchers. Data is an object for analysis: it is compared and similarities and differences are analyzed in order to look for new approaches to problems. This analysis has no meaning for the development of scientific research if it is not made public to other researchers. Again, similar to an information system, the results of the analysis are expected to be displayed to colleagues to feed further analysis and discussion.

Although we see similarities between information systems and scientific research, we do not contend that research is only possible with the use of information systems. Research can be carried out perfectly well without ICT and during the long history of scientific research it has been practiced more often without the help of ICT than with it. The study of the philosophy of science can also teach us that there is some similarity between ICT and research. However, it would be too great a step to suggest that this relationship is present in all the explanatory models of the philosophy of science, of which there are many. For example, Nagel discerned four basic models of explanation: the deductive model, the probabilistic explanation, the functional or teleological explanation, and the genetic explanation (Nagel, 1961). We restrict our reflection to three examples in order to show that different explanatory models in science make use of characteristics similar to information systems.

Hempel (1966) started his book *Philosophy of natural science* with the story of the detection of puerperal fever by Semmelweis in 19th century Vienna. Semmelweis observed that proportionally more mothers who gave birth in ward A of a hospital caught this terrible disease than in ward B of the same hospital. This observation helped Hempel to explain the inductive method in scientific research. In this example, Semmelweis made different hypotheses and tested whether they were true or not. Hempel described four stages that an ideal scientific inquiry has to pass through: 1) observation and recording of all facts, 2) analysis and classification of these facts, 3) inductive derivations of generalizations from them, and 4) further testing of the generalizations (see also Lundberg, 1968). Next, he criticized this explanatory model for different reasons. He refuted the possibility of collecting ‘all’ facts or even ‘all relevant’ facts, because the question then remained of ‘relevant for what?’ For a particular hypothesis, as “a tentative answer to a research problem,” Hempel (1966, p. 15) concluded that there are “no generally applicable ‘rules of induction’ that allow us to mechanically produce hypotheses or theories” and that scientific research is only inductive in a broad sense. This means that hypotheses are accepted based on data that give “more or less strong ‘inductive support’, or confirmation”, possibly expressed in probabilities. Inductive reasoning is of course based on more than the characteristics which are similar to an information system, but it captures data, in the same way an information system does. This data is then processed and sent to

different participants in a research project, and after all kinds of analysis, is stored for reconsideration when new data is collected.

The critique by Hempel of a narrow inductive research model was shared by Popper (1965; 1969). Popper stressed that there are many things we do not know, and history has shown that scientists started to observe systematically these domains, looking for regularly repeating characteristics of these phenomena. This in turn made it possible to formulate hypotheses to explain these phenomena. The next step for the researchers was to collect facts in order to verify or confirm these hypotheses. This is the inductive thinking method by researchers, an approach that was not accepted by Popper. He contended that our observations are limited and do not allow us to make general judgments about reality and how this reality will develop in the future. He suggested that a researcher should start from a problem and look for an answer to this problem by using a theory: a tentative answer to the problem. From the collection of facts that do not fit this tentative answer, the question emerges of why this is the case. This might be a reason to look for new data. Therefore, knowledge is always tentative and expects a continuous critical attitude. Popper's answer was not induction, but deduction and falsification. Tentative theories have to be questioned by looking for refutations. Truth is attained by checking whether a proposition is or is not true. The demarcation line between science and non-science lies in disproving a tentative proposition. In the same way as in the inductive explanation, scientific research in the deductive model is more than a collection of facts, but – also here as in an information system – the procedure shows an input of data, its processing by researchers, distribution among the researchers, and its storage.

However, the deductive model has also received much criticism. One critique was offered by Roy Bhaskar (1997) in terms of critical realism. In a critical reflection on the inductive explanation and falsificationism, Sayer (1992, p. 206) concluded that: "it is quite unreasonable to expect verifications and falsifications to be absolutely certain and conclusive". Popper's falsificationism was, according to Sayer (1992, p. 226), "virtually impossible to put into practice". Critical realism contends that a methodology should not be disconnected from an ontology. This is not the place to describe this ontology in detail. We simply offer some examples: "The world exists independently of our knowledge of it"; "There is necessity in the world; objects – whether natural or social – necessarily have particular causal powers or ways of acting and particular susceptibilities"; "The world is differentiated and stratified, consisting not only of events, but objects, including structures, which have powers and liabilities capable of generating events"; "Science or the production of any other kind of knowledge is a social practice" (Sayer, 1992: pp. 5-6). With regard to social sciences, Sayer (1992) opted for a research methodology where two types of research are applied: intensive research and extensive research. These research types are not opposed, but complementary. Intensive research focuses on answering questions about the causes of a particular

behavior in a group. To answer these questions, a researcher is supposed to carry out in-depth research of small groups and individuals, and corroboration is used to test the observations made about the group. Extensive research is interested in answers about the general characteristics of a population. To test whether these characteristics are also present in another population, a replication of the research should be carried out. Similar to the two former explanatory models, the different steps of an information system apply here: there is an input of data, stored for further activity by researchers and distributed among them for further discussion.

Given that the process of scientific research shows many of the same characteristics as an information system, we wonder whether students who are expected to be interested and trained in scientific research would also be keener to use ICT and to master ICT skills. This process can be explained in terms of *identity commitment*. Burke & Reitzes (1991) defined a form of commitment: “[that] refers to the sum of the forces, pressures, or drives that influence people to maintain congruity between their identity setting and the input of reflected appraisals from the social setting” (see also Berzonski, 2003; Johnson, 2007; Eteläpelto, Vähäsantanen, Hökkä, & Paloniemi, 2013). A university student has as an identity setting a definite belief in his or her academic competence, a vocational orientation, and an orientation toward becoming a professional. This orientation might refer to the profession of a scientific researcher, or many other professions. The characteristics of the identity setting can be supported or weakened by social contacts. If the commitment is weak, the actor may lose contact with the identity setting, but if the commitment is strong, the actor will stay close to the expectations of the group that link him or her to an identity setting. A reward system that supports the latter development will probably keep a student more committed to that identity. Two bases of commitment were discerned by Burke & Reitzes (1991). One base of commitment is cognitive: the actor perceives positive rewards from maintaining an identity that is supported by significant others. The second base of commitment is socio-emotional. Actors who have a positive experience when they follow the role of the significant others in their network and who feel that their behavior is supported by the network, will be more committed to maintain that role. On the basis of the theory of identity commitment, our hypothesis is that students who believe scientific research is part of their identity (as defined by significant others) will also be more inclined to master ICT skills and apply ICT. Therefore, in our research we want to predict the students’ ICT skills and ICT use not only by looking at variables related to the acceptance of technology and to the social context, but also at the students’ commitment to scientific research.

3. Methods of research

Bringing ideas from TAM together with identity commitment, our hypotheses are as follows. Students who find ICT useful and who think they have a satisfactory level of control of ICT will perceive

themselves to have better ICT skills and will also use ICT more frequently. This relationship will also hold for students who are less afraid of applying ICT and who are not reluctant to use a computer. Moreover, students who believe in their academic competence and in their vocational orientation will be more convinced of their own ICT skills and will use ICT more frequently. We also expect the same relationship with regard to a positive attitude toward scientific research, the intention of becoming a researcher, and a belief in the functional link between scientific research and ICT. Finally, we also assume that contextual factors such as gender, the domain of study, ICT training, and family culture will have an effect on the command of ICT and the frequency of ICT use.

Some parts of the hypotheses relating to technology acceptance have already been tested among freshers in earlier projects (Anonymous 3; Anonymous 2). With the orientation toward scientific research as an important addition, we opted for a new online questionnaire among bachelor's students at the same university in their second and third years. Older students were selected because they are more familiar with scientific research than freshers and are coming closer to the time when they will have to decide whether to become a researcher or something else. Some 3609 second and third year students received an email inviting them to participate and after two reminders (only sent to students who did not answer a previous invitation) 1232 had completed (between 13 November 2012 and 18 December 2012) a questionnaire containing 221 items. In the current analysis, only students younger than 26 are included, resulting in a final total of 1180 students. This is because those who were 26 or older are a minority and most of them are not full time students, which would harm the homogeneity of our sample. The representativeness of the sample was checked for gender, age, and faculty, which led us to calculate a weighting variable that was used in our analyses. It should also be mentioned that the observation took place in a large university, which has been established for centuries in a small Belgian town. Most of the students live in rooms with a high-speed broadband Internet connection. There are also plenty of computers at the disposal of the students in the university buildings. This university is termed as a 'research intensive university' and most faculties mention among the learning targets of bachelor's students all the types of skills a researcher needs in order to conduct research (UoU, 2012).

In order to answer our research questions, the following explanatory model was developed (see Figure 1):
(Figure 1 here)

As predictor variables, we use the key variables of TAM, variables related to identity commitment – in which the orientation toward scientific research is the most important part – and context variables. The

choice to use research orientation is justified, because the educational program of this university mentions scientific research as one of its intended learning outcomes and all the faculties repeat this objective.

Therefore, we can expect the students to have an orientation toward scientific research. The dependent variables are composed of the self-perception of all the types of ICT skills needed to work conveniently with a computer, and the frequency of ICT use.

3.1. Dependent variables

3.1.1. ICT skills

Many instruments have been used to measure self-perceived ICT skills. In previous research, we used an instrument with 19 items (Anonymous 3; Anonymous 2). However, because we were convinced that the ICT competences of students had evolved since our last survey, we engaged in a thorough revision of the research instrument. Based on a literature review (among them, ECDL, 2010), an initial measurement instrument consisting of 123 Likert-type items was created. This instrument was subjected to a pre-test using a sample of 85 university students. Items that did not perform well in Exploratory Factor Analysis (EFA) or Confirmatory Factor Analysis (CFA), were deleted, as well as items with low discriminating power (i.e. items that more than 15% of the sample could not answer and items that showed the maximum score from at least 80% of the sample). The final measurement instrument retained 49 of the 123 original items and was used in the current research project. These items encompass eleven ICT skills and a selection is presented in Table 1.

(Table 1 here)

The responses of the study participants were analyzed using CFA in Mplus 4.0. The results support an adequate model fit (CFI [comparative fit index] = 0.95; TLI [Tucker Lewis Index] = 0.95; RMSEA [root mean square of error approximation] = 0.03; SRMR [standardized root mean square residual] = 0.040). This confirms that our revised instrument measures the concepts as theoretically proposed. For the purpose of further analyses, EFA using SAS Proc Factor (method = ML) was used to obtain standardized regression based factor scores (DiStefano, Zhu, & Mîndrilă, 2009). These factor scores serve as dependent variables in the subsequent analyses.

3.1.2. Frequency of ICT use

The frequency of ICT use is measured by three sets of questions about the use of ICT for study, and three about non-study. The questions had the following structure: "During this academic year on average how often did you surf the Internet for study purposes?" This was repeated for email, chatting, goal-oriented searching on the Internet, downloading music or films, participating in newsgroups, and writing blogs or

wikis. For non-study purposes, this list was extended with questions about playing games on the computer or on the Internet.

The use of ICT hardware for study and non-study purposes was covered by questions concerning the use of a PC or laptop, the Internet, mobile phone, iPad or tablet, iPod, iPhone or smartphone, digital camera, and e-reader. The questions about the use of software for study and non-study purposes refer to: word processing, spreadsheets, databases, social networks, Twitter, virtual learning environments, drawing software, statistical programs, qualitative data analysis programs, and specialized software. All the questions concerning the frequency of ICT use could be answered by one of the following categories: daily (score = 6), four to five times a week (score = 5), two or three times a week (score = 4), weekly (score = 3), monthly (score = 2), less than once a month (score = 1), or never (score = 0). The average score for each student, calculated on all items of a variable, is used for further analysis.

3.2. Independent variables

3.2.1. Attitude of students toward ICT

The four core variables of TAM were measured by presenting the students with the scales proposed by Selwyn (1997). Together with the scales regarding ICT skills, the answers of the students were subjected to EFA, which provided standardized regression based factor scores for further analysis. CFA was also performed with Mplus 4.0, which shows adequate model fit (CFI = 0.94; TLI = 0.93; RMSEA = 0.03; SRMR = 0.041) for the four variables of TAM and the variables professional orientation and academic self-perception. Table 2 displays the meaning of each variable and an example of the items used in the questionnaire.

(Table 2 here)

3.2.2. Identity commitment

Five variables assess the identity commitment of the students. The first gauges the academic self-perception of students and the instrument devised by Bennett (2009) was used. This is a Likert-type instrument consisting of seven items, in which students are asked questions such as: “I rate myself highly in terms of my academic ability as an undergraduate”, and “I have great self-confidence in my ability to succeed academically at university”. The response options are the same as for the items regarding ICT skills.

The second variable is also a Likert scale. Here the extent to which a student is 'vocation directed' is measured (Vermunt, 1994). Among the five items of this instrument are: "What I want to acquire above all through my studies is a professional skill" and "The main goal I pursue in my studies is to prepare for a profession". The response options are the same as those for academic self-perception. The items measuring academic self-perception and professional or vocational orientation were included in the same factor analysis, which also included the items on ICT skills. EFA was used to calculate the standardized regression based factor scores for further analysis.

Three variables examine the orientation of the students toward scientific research. First, an instrument was constructed to measure the evaluation of scientific research. There is a wide choice available of scales assessing the appreciation of different disciplines (for example, Wareing, 1982, 1990; Germann, 1988; McCleary & Brown, 2003; Tuan, Chin, & Shieh, 2005; George, 2006; Kind, Jones, & Barnby, 2007; McCloskey, 2008; Bennett & Hogarth, 2009). We adapted the scale developed by Cheung (2009) to assess the appreciation of chemistry, into a scale to measure the appraisal of scientific research. This contains 12 items such as: "We should be given more space to conduct scientific research in our training", "Everyone should be familiar with scientific research because it touches everyone's life", and "I want to spend more time reading books on scientific research". EFA was applied to these items, which provided standardized regression based factor scores for further analysis.

Second, identity commitment also encompasses the intention of a student to become a researcher. Two Likert-type scales (13 items in total) examined this. The question "What do you expect from your later profession?" was followed by items such as: "I want to become a researcher at a university or college", "I want a job in which I will have some part in scientific research", and "I would like a job in which I can organize the work of others". EFA identified two dimensions in the items, and provided the standardized regression based factor scores for each dimension. The first dimension refers to the intention of a student to become a researcher and the second refers to the expectation of a student to work as something other than a researcher.

A third variable was used to find out whether students believe in the need to have a particular level of command of ICT skills in order to conduct scientific research (regardless of the possible relationship between research intention and ICT). Students were asked to rate their level of agreement with nine items, including: "A scientific researcher must be able to work properly with database software", "A scientific researcher must be able to solve basic computer problems", and "A scientific researcher must be able to make contacts with his colleagues using the Internet". EFA confirmed that these items load onto a single factor and regression based standardized factor scores were obtained for further analysis.

3.2.3. Context

As explained in section 2, the process of learning ICT skills and applying them should not be separated from the social context in which the skills are learned and applied. In previous articles, we have already shown that many researchers have reached the same conclusion (Anonymous 3; Anonymous 2). In this current research, we include five context variables. Three are included as dummy variables: Gender (the variable 'Female') was scored 1 for female and 0 for male, the variable 'Human' was coded 1 for humanities students and 0 for science students, and students having attended an ICT class in secondary school or a class at university where a computer is used were coded 1, while the others were coded 0.

To gauge the economic and cultural background of the student's family, the highest educational level of the parents is used. This is also a dummy coded variable, coded 1 for students with at least one parent having a minimum of a higher education diploma, and 0 for students whose parents did not have a higher education diploma. This is a fairly rough indicator for the economic and cultural background of the parents, but it is an important indicator for the economic and cultural position someone can attain in society.

3.2.4. Inspection of the hypotheses

First, we want to check the extent to which the independent variables predict the *self-perception of ICT skills and ICT use* of students. While linear regression analysis is usually the analytical tool of choice for this purpose, some of the dependent variables showed strong ceiling or floor effects (see Table 3) and linear regression models suffered from heteroscedasticity. To accommodate these characteristics of the data, censored linear regression analysis (also known as Tobit regression analysis) was used (Long, 1997). We also tested for multicollinearity, but this phenomenon was not present.

(here Table 3)

Second, we want to analyze the effect of the independent variables on the *frequency of ICT use*. This analysis does not suffer from the same problems. Table 4 does not show strong ceiling or floor effects. We therefore applied linear regression analysis to the data, and used robust regression where necessary (i.e. in the presence of heteroscedasticity).

(here Table 4)

4. Results

Before testing our hypotheses, in section 4.1 we provide a short, more general description of the level of knowledge of ICT skills, the frequency of ICT use, and the access to computers and the Internet. In section 4.2, we show the students' scores on the TAM variables and their views about scientific research. In section 4.3, we deal with the question of whether TAM and the attitude toward scientific research predict self-perceived ICT skills and the frequency of ICT use. A discussion and conclusion are provided in sections 5 and 6.

4.1. ICT skills, ICT use and access to computers and the Internet

Table 3 is very clear with regard to the students' self-perception of their ICT skills. A very large proportion of students score notably high for word processing skills (4.66 out of 5) and skills for collecting information with a web browser (4.6 out of 5). These two skills can be stated as belonging to the basic competences of students. Most students are also self-confident with regard to the basic actions for maintaining a computer (4.24 out of 5), and a large group are very familiar with presentation programs (4.12 and 4.16 out of 5). We see below that these skills are also very frequently used by a large group of students, which in turn may contribute to the command of these skills. Students have a less positive opinion about skills demanding greater technical knowledge: the technical use of browsers and all types of processing on spreadsheets. Nevertheless, the score is above the middle (score 3) of the scale. In addition, the average scores with regard to databases and the use of modern communication instruments are actually below 3 out of 5. Some comparative figures for five UK universities can be found in Jones et al. (2010).

This overall positive perception of the command of ICT skills is reflected in the use of computers and the Internet. Most students use a computer more than four times a week for surfing the Internet, emailing and chatting for non-study purposes, and for surfing the Internet for study purposes (score ≥ 5 out of 6) (see Table 5).

(Table 5 here)

Table 5 also shows that a computer is more frequently used for non-study purposes than for study. The most important functions of a computer have been mentioned above. Only a minority of students use a computer to download music or films, are engaged in newsgroups and/or write a blog. Playing games is also not an important function for the computer (which might be contrary to popular expectations). In the academic year in our research, only 6% of the students played games on the Internet or on a computer daily, and about 48% never played games.

(Table 6 here)

Table 6 shows that a computer and the Internet are almost as important as food for a student. Without them, life and study are almost unimaginable. The mobile phone might only be an instrument for study for a minority (score 2.87 out of 6), but for a large majority (5.51 out of 6) it is an indispensable tool for daily life. Only 18% use a mobile daily for study purposes, but 86% use one daily for non-study purposes. Although tablets, MP3 players, and smart phones can be deployed in education, only a very small group of students do so. These instruments are mainly used for purposes other than study, by respectively 5%, 26%, and 26% of the students. The same applies to digital cameras and e-readers, which are also only used by a very small minority. This is in line with the finding of Woody, Daniel, and Baker (2010) that at present, e-readers have not yet been accepted in the Belgian academic world as an instrument useful for study.

(Table 7 here)

Table 7 shows that most ICT programs are more frequently used for study than for other purposes, except for SNS, Twitter, and drawing programs. Contrary to the findings of earlier research (Anonymous 1), SNS now seem to be used by a significant number of students for study purposes (score 3.38 out of 6). Virtual learning environments are frequently used by students for study, but a minority also use these programs for non-study purposes. The low frequency of using statistical programs, programs for qualitative analysis, and other specialized software is probably a consequence of the specificity of each individual domain of study and the concurrent need for specific ICT tools.

Table 4 shows the global average scores for the use of a computer and the Internet, ICT instruments, and ICT programs. Computers and the Internet are more frequently used by students for non-study purposes than for study. This is clearly shown when we look at the *functions* fulfilled by a computer in the daily life of a student: 54% of the students surf the Internet daily in connection with study, but for non-study purposes this figure is 84%. A similar picture emerges for emailing and chatting: 51% of the students send daily e-mails related to study, whereas the figure is 74% for non-study purposes; 29% chat daily about study subjects, 62% for other reasons. We can say that the computer and the Internet hold a major position in the life of a student, but are used more outside of study than for study reasons.

A similar pattern is found for the use of *ICT instruments*: they play a more important role for non-study related actions than for study. Some 73% of the students use a computer daily for study purposes, 92% for other purposes. Daily, more than 50% of the students go onto the Internet for study, and more than 80% for other reasons. All the other instruments have a more important function for non-study purposes than for study. A mobile phone is used by 18% for study, but by 86% for other purposes. The other instruments mentioned in Table 6 are barely used for study at all: 86% never used an iPad or tablet for study during

this academic year, 87% never used an iPod or MP3 player, 76% never used an iPhone or smart phone, 80% never used a digital camera, and 92% never used an e-reader.

With regard to the use of *ICT programs*, Table 4 shows a higher total score for the use of ICT programs for study, which as we mentioned before might be the result of the selection of the ICT programs in the survey. Most programs can be said to be useful for study related tasks as well as for non-study related tasks, but the table shows that all programs are used more for study purposes. Only Twitter and SNS have no direct function for study.

It has to be stressed that almost all the students have a computer for their own use, together with broadband Internet access. Students living in rooms in town (82% of the students) have this type of connection both at home and in their room in town. Moreover, an Internet connection is available to all students at many places in this university. Our figures show that desktop computers have almost disappeared: only 7% of the students work mostly with a desktop. Most students (88%) work with a laptop, 3% with a notebook, and the rest with netbooks or tablets.

A large proportion of these students come from families where computers and the Internet have an established position. Some 85% of the students have at least one parent with a higher education diploma and 63% of the mothers and 77% of the fathers have a job where a computer is used. The use of a computer at home by parents and siblings scores 2.67 out of 3, indicating that for most students, a computer is a daily tool that has a natural place in their life. This is confirmed by the age at which the students started to use a computer: a quarter of them were younger than 10 and the average age is only 11.91 years. Although most of the students probably received a lot of information about computers and the Internet from their family, they indicate that they learned predominantly from self-study (score 3.5 out of 4) and less from peers (2.51 out of 4), teachers (1.72 out of 4), and family (1.63 out of 4).

4.2. Attitude toward ICT and scientific research

Given the social background of the students and the expectations of the university, it is almost self-evident that most students will show an open mind toward ICT. Table 8 provides a clear picture of this openness.

(Table 8 here)

Most students consider a computer as something useful (at least for some tasks) and at the same time believe that they have an appropriate command of computers. Only a small number of students feel some anxiety about working with a computer or show some reluctance to work with one.

Since these youngsters are second or third year bachelor's students, they have already gained some confidence in their academic capacities (see Table 9), although a score of 3.3 out of 5 is not notably high. Most also think that their choice of university was the correct decision with regard to the profession they envisage.

(Table 9 here)

Although one of the intended learning outcomes for all faculties at this university is the ability to carry out scientific research, the students' appraisal of scientific research is not very high (score 3.27 out of 5). A quarter of the students score lower than 2.86; below the middle score. This low appraisal translates into the intention of becoming a researcher also being low on average (score 2.56 out of 5). On this item, the lower quarter of the students score as little as 1.96 out of 5. The students are clearly more interested in becoming a consultant, a teacher, a manager, or something else (score 3.17 out of 5). Although a large proportion of the students do not aspire to become a researcher, they strongly believe that being a researcher and a knowledge of ICT go hand in hand (average score 4.02 out of 5; the upper quartile scores 4.4 or higher).

4.3. TAM and identity commitment as predictors for ICT skills and the frequency of ICT use

In section 2, we proposed the hypothesis that the basic variables of TAM and attitudes supporting the identity commitment of an actor (taken here as a positive orientation toward scientific research) would deliver better predictions for ICT skills and the ICT use of students. Table 10 and Table 11 confirm this hypothesis. Nevertheless, these tables also show that the confirmation is not equally strong for all ICT skills or for all forms of ICT use. In Table 10, the results of the model for *ICT skills* are shown.

(Table 10 here)

TAM, identity commitment, and the context variables explain 52% of the variance in computer maintenance skills and 40.5% of the variance in the skills needed for the technical use of a browser. Our model explains smaller parts (between 28.9% and 22.1%) of the variance in most other skills: working with a word processor, a spreadsheet, or a presentation program; information collection using a browser; and communication. Only 11.3% of the variance in working with a database is explained. We have already seen above that students do not report high skills for working with databases.

Table 10 also shows that not all the variables in our model contribute equally to the explanation of the variance. Only one variable significantly improves the prediction of all ICT skills in Table 10: the belief in

having control over computers (Arenas-Gaitán et al., 2011; Chow et al., 2012a; Chow et al., 2012; Huffman & Huffman, 2012; Terzis & Economides, 2011; Terzis et al., 2012). Anxiety about working with a computer is significant in explaining nine ICT skills (Jahromi et al., 2010; Mazloumiyan et al., 2011; Huffman & Huffman, 2012; Celik & Yesilyurt, 2012; Nistor et al., 2012). Gender and the belief in the usefulness of computers each improve the prediction of eight ICT skills. The conviction that scientific research requires an appropriate knowledge of ICT improves the prediction of seven. The study domain of the students improves the prediction of five. The attitude toward scientific research and having attended ICT classes in secondary school improve the prediction of two. Contrary to our expectations, the intention of becoming a scientific researcher or something else predicts only two ICT skills, as does the education level of the parents. Behavior expressing a negative attitude toward computers predicts only one of the eleven ICT skills. No predictions concerning ICT skills are significantly improved by the academic self-perception and the vocational orientation of the students.

It is interesting to see that our model works best in explaining the skills for working with a digital spreadsheet: seven to eight predictors help to improve the prediction of these skills. Six variables improved the prediction of work on data of a presentation program and five variables the prediction of the change of a presentation and information collection with a browser (see Table 10).

The parameters in Table 10 confirm that students having control over a computer (between $b = 0.694$ and $b = 0.395$) and seeing the use of a computer as useful for work (between $b = 0.261$ and $b = 0.098$), see themselves as skilful ICT users (Anonymous 3; Carlsson, Carlsson, Hyvönen, Puhakanen, & Walden, 2006; Chatzoglou et al., 2009; Cho, Cheng, & Lai, 2009; Lee, 2010; Teo et al., 2009; Wang, Wu, & Wang, 2009; Wu, Tao, & Yang, 2007). Students who see computers as useful for their work report a higher level of skills for two of the spreadsheet skills, the two presentation and browser skills, and communication skills. The figures also confirm that students who experience some anxiety about working with a computer master fewer skills for the maintenance of a computer ($b = -0.313$), for word processing ($b = -0.392$), and for working with digital spreadsheets, presentation programs, and browsers.

A positive attitude toward research significantly supports the skills for maintaining a computer ($b = 0.115$), word processing ($b = 0.175$), and using presentation programs ($b = 0.162$ and 0.121). Students with the intention of becoming a scientific researcher are more inclined to master skills for performing calculations ($b = 0.149$) and style changes ($b = 0.121$) in digital spreadsheets. Students who are not oriented toward scientific research score higher for working with data in a presentation program ($b = 0.113$) and communication ($b = 0.117$). Students who believe that a researcher should have appropriate knowledge of ICT skills report a higher level of skills in word processing ($b = 0.233$), working with digital

spreadsheets (between $b = 0.087$ and $b = 0.120$), presentation programs ($b = 0.134$ or 0.166), and collecting information using a browser ($b = 0.143$).

It has often been shown that women and men take a different stance concerning ICT (Colley & Comber, 2003; Losh, 2004; Volman & van Eck, 2001; van Dijk & Hacker, 2003; Hu, Zhang, Dai, & Zhang, 2012). The parameters in Table 10 confirm this for the basic skills to maintain a computer, working with spreadsheets or a browser, and communication, for which female students score significantly lower than male students (between $b = -0.176$ and $b = -0.810$). For word processing skills, female students score significantly higher than male students ($b = 0.269$).

The domain of study as an explanatory variable accounts for lower reported skills by humanities students than by science students with regard to working with spreadsheets (between $b = 0.282$ and $b = 0.659$) or with a word processor, but higher skills for working with databases ($b = 0.576$). In general, students assess their skills to work with spreadsheets and databases lower than other ICT skills.

It was expected that having attended an ICT course in secondary school would have a positive effect on mastering ICT skills at university. This is only confirmed for working with a database ($b = 0.334$) and for the three skill categories of working with a spreadsheet (between $b = 0.250$ and $b = 0.263$). The effect of attending classes at university where a computer is used is even less, and is only significant with regard to working on data in a presentation program ($b = 0.218$; not included in Table 10). Students sitting in such classes show fewer skills for working on data in a presentation program.

The other explanatory variables do not play an important role in explaining ICT skills. The educational level of the parents does not have the expected influence. A significant relationship with the educational level of the parents is only found for the technical use of a browser and word processing (respectively $b = -0.221$ and $b = -0.263$). Further, this relationship is negative: students from families with parents who graduated in higher education report lower skills in the technical use of a browser and in word processing. The academic self-perception and vocational orientation of the students also does not have any significant relationship with the self-perception of ICT skills. Finally, having a negative attitude toward computers is significantly related only (and unexpectedly) with higher self-perceived skills for collecting information with a browser ($b = 0.189$).

(Table 11 here)

Our model seems to be less powerful in explaining the *frequency of ICT use*, as shown in Table 11. It explains 18.4% of the variance in the frequency of computer use for non-study purposes. The figures for

the other categories of ICT use are much lower. Only 7.8% of the variance in the frequency of computer use for study purposes is explained by this model, 6.8% of the use of ICT instruments for study and 5.8% for non-study purposes, and 9.9% of the use of ICT programs for study and 8% for non-study purposes.

The best predictor for the frequency of ICT use is the perceived usefulness of ICT (see also Huffman & Huffman, 2012). This variable contributes significantly to the explanation of five dependent variables (it only has no significant effect for the prediction of the frequency of use of ICT instruments for non-study purposes). The intention to aim for a non-research oriented job and the domain of study each improve the prediction of four dependent variables. Gender and control over the computer improve the prediction of three dependent variables. The opinion that ICT is necessary for scientific research and anxiety about using computers improve the prediction of two dependent variables. The other explanatory variables have a significant effect for only one form of frequency of ICT use; these are a negative attitude toward computers, vocational orientation, the attitude toward scientific research, the intention to become a researcher, and participation in university classes where a computer is used. No effect is observed for attendance of ICT classes in secondary school or the educational level of the parents.

The prediction of the frequency of computer use for study is best supported by the belief of the students that scientific research requires ICT. The more positively they view this relationship, the higher the frequency of computer use for study ($b = 0.135$). The same relationship is found with regard to the intention of having a non-research orientated job, vocational orientation, and the opinion that a computer can be useful. Moreover, our figures show that humanities students use a computer more frequently than science students and that female students use a computer less frequently for study than male students do.

The use of a computer for non-study purposes is higher among men than among women ($b = -0.366$). The frequency of use for non-study purposes is higher among students who are not anxious about working with a computer ($b = -0.082$), who think that a computer can be useful ($b = 0.113$), who believe that they have control over a computer ($b = 0.215$), or who study humanities ($b = 0.160$).

The frequency of use of ICT instruments for study is higher for students who think that a computer is useful ($b = 0.120$), who feel they have good control of a computer ($b = 0.081$), who expect to have a job that is not oriented to research ($b = 0.193$), or who have a positive attitude toward scientific research ($b = 0.087$). Surprisingly, students with a low motivation to become a scientific researcher ($b = -0.135$) use ICT instruments more frequently for study.

For non-study purposes, the frequency of the use of ICT instruments is significantly and positively related to self-perceived control over a computer ($b = 0.129$), the motivation to find a non-research oriented job (b

= 0.065), and studying humanities. Students scoring high for these three variables more frequently use ICT instruments for non-study purposes.

Finally, with regard to the frequency of using ICT programs, the frequency of use for study is higher for students believing in their control of a computer ($b = 0.178$), students expressing a negative attitude toward computers ($b = -0.125$), students agreeing that there should be a link between ICT and scientific research ($b = 0.123$), male students ($b = -0.070$), and humanities students ($b = -0.106$). It is strange to see that students who have more computer anxiety use ICT programs more frequently for study ($b = 0.089$). It remains unclear as to why this relationship exists.

The frequency of use of ICT programs for non-study purposes can be significantly better predicted by two predictors. Students who believe that computers are useful ($b = 0.177$) score higher, as well as students who are more motivated for a non-research orientated job ($b = 0.105$).

5. Discussion

The main purpose of our article is twofold: to build an instrument to measure ICT skills in greater detail than in previous studies, and with that more detailed view, to expand existing explanations for the mastery of ICT skills by adding the orientation of students toward science as an additional explanatory factor.

There is ample literature on students' ICT skills and ICT use and the factors that explain the acceptance of new technology (TAM). We also have some indications with regard to the role of contextual factors, academic self-perception, and professional orientation (see our former research). Further, there are existing studies about teaching STEM (science, technology, engineering, and math) and the use of ICT in classrooms. With our current research, we have been able to add to this body of literature by looking not only at the acceptance of new technology, but also at its continued use, and moreover by including the orientation toward science in our explanatory model. This is the first study about ICT skills and the ICT use of students that takes into account their training to become a scientist. Of course, not all students want to become a researcher. However, at research universities, students are trained in carrying out research and hence will experience both the benefits and the problems of working with ICT in this regard. We took as a starting point (our hypothesis) that students who are interested in research and believe ICT is necessary for research will value ICT more highly and therefore will have better ICT skills and use ICT more (controlling for other variables).

To investigate this hypothesis – not with regard to the general level of ICT mastery but a detailed level of particular skills – we developed new instruments to measure the self-perception of ICT skills among students on the one hand and the frequency of ICT use on the other. A new instrument comprising 49 items was developed on the basis of a literature review and a pre-test, to measure the self-perception of ICT skills among students. This provided a more representative and diversified picture than previous instruments. However, it must be noted that the assessment of skills was made by the students themselves. It is therefore possible that the self-assessment does not correspond exactly to factual behavior. It should also be noted that SNS are not included in the scales measuring the command of ICT skills. This is an intentional omission, based on the observation that most students are familiar with SNS (Anonymous 4), and therefore its discriminating power is low. A new instrument was also constructed for measuring the frequency of ICT use. This instrument distinguishes between the use of a computer and the Internet, the use of ICT instruments, and the use of software. For each of these categories, respondents were asked to score their use for both study and non-study purposes. By including in the new instrument items regarding more (and hence, also more rare) functions, instruments, and programs, we are able to observe more diversification in the responses. However, it should be borne in mind that some specialized software included in the scale measuring the frequency of use of ICT programs is more functional for study activities than for non-study purposes.

The core variables of TAM (Davis, 1989) are given great emphasis in this study. Although TAM was originally intended for studying the acceptance of new technology, it has been shown that TAM can be equally useful to explain the expanding adoption, or lack thereof, of existing technology. It is clear that TAM has to be seen in a context, which in this case is a university where scientific research is one of the intended learning outcomes. As scientific research has similar characteristics to ICT systems, we hypothesized that a positive attitude toward scientific research would lead to a (self-perceived) higher level of ICT skills and a higher frequency of ICT use.

This is confirmed in several instances (see Table 10), but surprisingly not with regard to skills relating to digital spreadsheets and databases, two techniques that nonetheless seem important for research. In addition, the more students are positive toward research, the more frequently they use ICT instruments for study purposes, but this is not the case for the use of a computer or ICT programs (see Table 11). Further research is needed to explain why no difference in the level of database and spreadsheet skills and the frequency of use of a computer or ICT programs can be found among these students. Similarly, the effect of the intention to become a researcher is not as expected, leaving a number of questions open for further investigation. For instance, why are students who intend to become a researcher not better in terms of database skills than other students, although they have better skills at working with spreadsheets? Do they

attribute a different function to each, or is it an expression of less previous learning experience with databases? Further, why do students who intend to become a researcher have a lower frequency of use of ICT instruments for study? Do they see the logic of science as being more important than the instruments used to do some supporting (more technical) work?

Another unexpected observation is that students who do not intend to become a researcher see themselves as more capable of working on data or on presentations, and generally speaking make more frequent use of ICT both for study and non-study purposes. This seems to imply that students who are more interested in jobs other than research see more benefits in coming to terms with ICT than research-oriented students. This is again an observation that requires additional research.

Students who think that ICT is necessary for research are better at working with word processing, spreadsheets, presentation programs, and information collection with a web browser. This raises the question of whether the belief that ICT is necessary for a researcher is a proxy for expressing interest in becoming a researcher, or that it is simply a reiteration of what they hear from their teachers: that ICT is very important and belongs to the learning targets that students have to achieve.

ICT use is widespread and strongly integrated in higher education in many cultures and therefore the observations made in this study may provide solid foundations for the study of similar phenomena in other universities and in other countries. However, some caution should be taken when extrapolating the findings of this research to bachelor's students in other settings. Culture and tradition might be different in other universities and countries and might lead to different results (Lai, Wang, & Lei, 2012). We must also be aware of the above-mentioned questions that are as yet unanswered and that in the first place invite further investigation. For example, future (qualitative) research might benefit from a focus on master's programs (instead of bachelor's programs), because at that stage the decision students make about their future job and career is nearer.

6. Conclusion

The analyses presented in this article clearly show that most bachelor's students are very familiar with basic ICT skills such as word processing, presentation programs, searching for information with a browser, or the maintenance of a computer. This is much less the case for working with spreadsheets, databases, or modern forms of communication. It is also clear that most students use a computer and surf the Internet daily. Nevertheless, this does not mean that they use all the functions of a computer or the Internet on a day to day basis, or that they use all kinds of ICT instruments or ICT programs every single day. For example, only some 4% of the students indicated they had not worked with a word processor

during the academic year, but 39% had not worked with a spreadsheet and 59% had not worked with a database. This proves our point that 'ICT' is such a broad term that in research it is necessary to include many functions, instruments, and programs, because unequal skills and uses only come to the fore at a detailed level. Even 'digital natives' do not master every aspect of ICT, although this is a popular belief.

The results of our analyses show that the model combining the four basic TAM variables with the identity commitment of students (focused on the appreciation of scientific research) and some context variables, can explain a substantial part of the variance in different ICT skills, but considerably less of the frequency of ICT use.

With regard to ICT skills, the hypotheses we presented in section 3 with regard to the TAM variables are largely confirmed, but not for all aspects of ICT skills or for all forms of ICT use. Students who believe they have more control over a computer also rate more highly their command over all aspects of ICT than other students do. This is generally also true for those who find a computer useful, but not for all aspects of ICT skills (Arenas-Gaitan et al., 2011; Chow et al., 2012a; Chow et al., 2012b; Huffman & Huffman, 2012; Terzis & Economides, 2011; Terzis et al., 2012). Students who show more anxiety about computers see themselves as less capable of applying most ICT skills (Jahromi et al., 2010; Mazloumiyan et al., 2011; Huffman & Huffman, 2012; Celik & Yesilyurt, 2012; Nistor et al., 2012). The behavioral expression of little appreciation for the use of a computer is less successful as a predictor of ICT skills. Only in one case does it exert an influence, and this is in an unexpected and difficult to understand direction.

The variables expressing the identity commitment of students to their position and their attitude toward scientific research are less fruitful for the explanation of ICT skills than the TAM variables are. Vocational orientation or academic self-perception do not contribute to a better understanding of ICT skills. Our hypothesis in section 3 is not proven. The most fruitful variable is found in the opinion of students about the necessity of having the appropriate knowledge of ICT to carry out scientific research. Students scoring high for this variable also score high for seven of the eleven ICT skills. A positive attitude toward scientific research also goes together with higher scores for the skills of maintaining a computer, working with a word processor, or working with presentation programs, but not with other skills. Furthermore, we hypothesized that students who intend to become a scientific researcher would also indicate a higher level of ICT skills, but this is only confirmed for two of the skills related to spreadsheets and not for other skills. Similarly, the intention of students to become something other than a scientific researcher coheres with only two skills: working on data in a presentation and communication skills. Moreover, even the hypothesis that students not oriented toward scientific research would nevertheless be convinced of the usefulness of ICT for their job, has to be refuted.

Turning to the context variables, it is well known that women take a different stance than men toward ICT. This hypothesis is confirmed for seven out of the eleven ICT skills: female students generally think less of their ICT competences than male students do. The exception is word processing, with females giving themselves a significantly higher score than males.

It was hypothesized that students in humanities would differ from science students in terms of their ICT skills. This is confirmed for skills related to spreadsheets and word processing, for which humanities students indicate a lower level of skills, and skills related to databases, for which science students believe themselves to be less capable. It is unclear why, compared with science students, humanities students consider themselves good at working with databases, but not spreadsheets.

What students learned in high school in relation to ICT, their participation in a class at university where a computer is used, and the educational level of the parents of the students, are all context variables that do not appear to have a large influence on ICT skills.

Our model is less able to explain the frequency of ICT use. Even the best fit, regarding influences on the frequency of computer use for non-study purposes, does not explain more than 18% of the variance. Other variables are clearly needed in order to understand the frequency of ICT use better. This is an area where the power of the two TAM variables is well illustrated. The more students find computers useful or the more they are in command of a computer, the more frequently they use a computer, ICT instruments, or ICT programs (Huffman & Huffman, 2012). This general statement of course does not hold for each and every aspect of ICT use, as shown above.

Two other variables play an important role in explaining the frequency of ICT use: the students' intention of having a job not oriented to scientific research, and gender. Students inclined to look for a job outside scientific research use a computer or ICT instruments more frequently for study, and use ICT instruments and software more frequently for non-study purposes than do students oriented toward a job in scientific research. Women generally use ICT less frequently than men, although for the use of ICT instruments no significant difference is found between male and female students. All the other variables in our model relating to the identity commitment of the students play a minor role. We only found that high scores for vocational orientation and for the appreciation of the need of ICT for scientific research go together with high scores for the use of a computer for study, and that students who believe that scientific research needs ICT competences also score high for the use ICT programs. Our finding that what students learned in secondary school about ICT and the education level of the parents do not seem to have an impact on the frequency of ICT use seems to suggest that, once at university, students of all kinds of backgrounds develop a rather similar pattern of ICT use.

In conclusion, the results of our study show that the ICT skills of bachelor's students can be predicted reasonably well by looking at their openness toward ICT. However, contrary to our expectations, openness to ICT does not predict the frequency of ICT use, and openness to scientific research does not seem to be related to either ICT skills or ICT use.

In other words, what is shown foremost is that the variables derived from a model regarding the acceptance of new technology have equally proven their value in our model related to the sustained use of technology, and that these variables can be used to explain differences in (self-perceived) skills in ICT use, especially when looking into a detailed level of a variety of skills.

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Table 1. Scales of ICT skills and item examples

ICT skills and subscales	Item example
Maintenance (7 items) (Cronbach's $\alpha = 0.86$)	- I can close a non-responsive program.
Word processor (6 items) (Cronbach's $\alpha = 0.84$)	- I can put special characters, such as Ÿ, S, O, Ç, in my text.
Digital spreadsheets	
- Calculate (3 items) (Cronbach α 's = 0.94)	- In digital spreadsheets I can compute simple calculations (addition, subtraction, multiplication, division).
- Style change (8 items) (Cronbach's $\alpha = 0.93$)	- In a digital spreadsheet I can format the cells so that numbers with a specific number of decimal digits are displayed.
- Work on graphs (3 items) (Cronbach's $\alpha = 0.92$)	- In digital spreadsheets I can add data labels (e.g. scores,%) to a chart.
Database (6 items) (Cronbach's $\alpha = 0.98$)	- In a database program I can open a table, a form, or a query.
Presentation program	
- Work on data (4 items) (Cronbach's $\alpha = 0.93$)	- I can enter data in a presentation program to create a chart.
- Presentation change (2 items) (Cronbach's $\alpha = 0.71$)	- I can change the position of a slide with the help of the slide sorter of a presentation program.
Browser	
- Technical use of browser (4 items) (Cronbach's $\alpha = 0.82$)	- I can delete temporary internet files (cache) from my webbrowser.
- Information collection (3 items) (Cronbach's $\alpha = 0.75$)	- I can print an Internet page from my web browser.
Communication (3 items) (Cronbach's $\alpha = 0.72$)	- I can call my friends with Voice over IP (e.g. Skype, SIPdiscount, Voiceglobe, etc.) even if they do not have Voice over IP.

Table 2. Scales related to TAM and identity commitment and item examples

Scales	Item example
TAM	
- Usefulness of computers (5 items) (Cronbach's $\alpha = 0.70$)	- Computers make it possible to work more productively.
- Control of computers (4 items) (Cronbach's $\alpha = 0.66$)	- If I get problems using the computer, I can usually solve them one way or the other.
- Anxiety (5 items) (Cronbach's $\alpha = 0.77$)	- I hesitate to use a computer in case I look stupid.
- Behavior expressing a negative attitude towards PC (3 items) (Cronbach's $\alpha = 0.67$)	- I only use computers at school when told to use.
Identity commitment	
- Academic self-perception (6 items) (Cronbach's $\alpha = 0.72$)	- I rate myself highly in terms of my academic ability as a student.
- Professional or vocational orientation (6 items) (Cronbach's $\alpha = 0.73$)	- For the kind of work I would like to do, I need to have studied at a university.
- Attitude towards scientific research (12 items) (Cronbach's $\alpha = 0.87$)	- I would enjoy university more if they did not bother us with scientific research.
- Intention to become a researcher (7 items) (Cronbach's $\alpha = 0.90$)	- I want to become a researcher at a university or college.
- Intention to become not a researcher (5 items) (Cronbach's $\alpha = 0.68$)	- In the future I want to teach.
- Necessity of ICT for a researcher (9 items) (Cronbach's $\alpha = 0.86$)	- A researcher must be able to properly work with an imaging program.

Table 3. Average scores (range 1-5), standard deviations, and lower quartile of ICT skills

ICT skills	Mean score (N)	Standard deviation	Lower quartile
Maintenance of PC	4.24 (1169)	0.83	3.70
Word	4.66 (1171)	0.59	4.57
Digital spreadsheets			
- calculation	3.91 (1169)	1.28	3.00
-style change	3.68 (1159)	1.14	2.95
-work on graphs	3.89 (1163)	1.24	3.00
Database	2.53 (1162)	1.41	1.00
Presentation program			
-work on data	4.12 (1167)	1.07	3.51
-presentation change	4.16 (1173)	1.00	3.57
Browser			
-technical use of browser	3.89 (1172)	1.20	2.88
-information collection	4.60 (1171)	0.70	4.26
Communication	2.93 (1173)	1.32	1.90

Table 4. Average frequency (range 0-6) and standard deviation of ICT use by bachelor students

	Mean score	Standard deviation
Frequency of PC use for study	2.61	0.84
Frequency of PC use not for study	2.91	0.80
Frequency of use of ICT instruments for study	2.05	0.65
Frequency of use of ICT instruments not for study	3.05	0.67
Frequency of use of ICT programs for study	1.70	0.59
Frequency of use of ICT programs not for study	1.34	0.66

Table 5. Frequency of computer use for study and not for study (average score; standard deviation; t test; range 0-6)

Function of computer use	For study		Not for study	
	Mean score	Std dev	Mean score	Std dev
Surfing	5.01	1.30	5.71***	0.82
Email	4.91	1.37	5.36***	1.14
Chatting on the Internet	3.74	1.96	5.00***	1.62
Purposive Searching on the Internet	4.33	1.33	4.71***	1.40
Downloading music	0.93	1.54	2.33***	1.84
Downloading films	0.77	1.36	1.83***	1.84
Newsgroups	0.91	1.58	1.03**	1.77
Writing blogs or wikis	0.28	0.84	0.27	0.89
Games on Internet	-	-	1.42	1.82
Games on PC	-	-	1.44	1.84

*p<.05

** p<.01

*** p<.001

Table 6. Frequency of use of ICT instruments for study and not for study (average score; standard deviation; t-test; range 0-6)

ICT instruments	For study		Not for study	
	Mean score	Std dev	Mean score	Std dev
PC	5.56	0.87	5.88***	0.49
Internet	5.56	0.82	5.90***	0.40
Mobile phone	2.87	2.22	5.51***	1.48
Ipad or tablet	0.47	1.31	0.88***	1.76
MP3 or Ipod	0.40	1.20	3.01***	2.37
Iphone or smart phone	1.01	2.00	1.71***	2.65
Digital camera	0.32	0.77	1.26***	1.36
e-reader	0.20	0.84	0.21	0.89

*p<.05

** p<.01

*** p<.001

Table 7. Frequency of use of ICT programs for study and not for study (average score; standard deviation; t test; range 0-6)

ICT programs	For study		Not for study	
	Mean score	Std dev	Mean score	Std dev
Word processor	3.48	1.51	2.23***	1.66
Digital spreadsheet	1.29	1.43	0.77***	1.30
Database	0.83	1.27	0.25***	0.79
Presentation program	1.92	1.52	0.53***	1.76
SNS	3.38	1.91	5.18***	1.75
Twitter	0.15	0.69	0.57***	1.48
Virtual learning environment	5.42	1.07	0.77***	1.70
Drawing	0.45	1.03	0.45	1.00
Statistical program	0.44	0.94	-	-
Qualitative analysis	0.19	0.72	-	-
Other software	1.20	1.65	-	-

*p<.05

** p<.01

*** p<.001

Table 8. Average score (range 1 – 5) and standard deviation of TAM key variables

Scales	Mean score	Standard deviation
- usefulness of computers	3.77	0.80
- control of computers	3.59	0.90
- anxiety	1.60	0.66
- behavior expressing a negative attitude towards PC	1.76	0.77

Table 9. Average score (range 1 – 5) and standard deviation of academic and scientific research orientation scales

Scales	Mean score	Standard deviation
Academic self-perception	3.30	0.76
Vocational or professional orientation	3.60	0.84
Attitude towards scientific research	3.27	0.67
Intention to become a researcher	2.56	0.88
Intention to become not a researcher	3.17	0.71
ICT, a requisite for a researcher	4.02	0.58

Table 10. TAM and Identity commitment as predictors of ICT skills (censored regression model (Proc Qlim tobit specification)).

Predictors	Maint	Word	Digital Spreadsheet			Database	Presentation program		Browser		Commun
			XLS1 calcula- tion	XLS2 Style change	XLS3 Work on graphs		PPT1 Work on data	PPT2 Presenta- tion change	BROWS1 technical use of browser	BROWS2 Informa- tion collection	
Intercept	0.510	0.689	0.893	0.283	0.653	-0.808	0.318	0.429	0.789	1.224	0.223
Use	-	-	-	0.106*	0.136*	0.174*	0.261***	0.175**	0.098*	0.182*	0.157***
Control	0.651***	0.425***	0.373***	0.405***	0.394***	0.395***	0.597***	0.412**	0.633***	0.694***	0.497***
Anxiety	-0.313***	-0.392***	-0.208**	-0.124**	-0.133*	-	-0.185**	-0.175**	-0.133**	-0.544***	-
Behavior negative for PC	-	-	-	-	-	-	-	-	-	0.189*	-
Academic self-perception	-	-	-	-	-	-	-	-	-	-	-
Professional orientation	-	-	-	-	-	-	-	-	-	-	-
Attitude scientific research	0.115**	0.175*	-	-	-	-	0.162*	0.121*	-	-	-
Intention become not researcher	-	-	-	-	-	-	0.113*	-	-	-	0.117**
Intention become researcher	-	-	0.149*	0.121**	-	-	-	-	-	-	-
ICT necessary for researcher	-	0.233*	0.120*	0.091**	0.087*	-	0.134**	0.166***	-	0.143*	-
Female	-0.580***	0.269*	-0.316***	-0.185**	-0.176*	-	-	-	-0.810***	-0.529***	-0.257***
Human	-	-0.227*	-0.659***	-0.282***	-0.570***	0.576***	-	-	-	-	-
ICT in sec school	-	-	0.250*	0.259**	0.263*	0.334*	-	-	-	-	-
Parents HE graduates	-	-0.263*	-	-	-	-	-	-	-0.221*	-	-
R ²	0.521	0.234	0.234	0.289	0.247	0.113	0.233	0.221	0.405	0.277	0.242

*p<.05

** p<.01

*** p<.001

Table 11. TAM and identity commitment as predictor of frequency of use of the PC, ICT instruments or ICT programs (linear regression analysis; standardized parameters)

Predictors	Frequency of use of PC for study ^b	Frequency of use of PC not for study ^a	Frequency of use of ICT instruments for study ^b	Frequency of use of ICT instruments not for study ^b	Frequency of use of ICT programs for study ^b	Frequency of use of ICT programs not for study ^b
Intercept	0	2.927	0	0	0	0
Use	0.091*	0.113***	0.120**	-	0.178***	0.177***
Control	-	0.215***	0.081*	0.129**	-	-
Anxiety	-	-0.082*	-	-	0.089*	-
Behavior negative for PC	-	-	-	-	-0.125**	-
Academic self-perception	-	-	-	-	-	-
Professional orientation	0.072*	-	-	-	-	-
Attitude scientific research	-	-	0.139**	-	-	-
Intention become not researcher	0.080*	-	0.087**	0.065*	-	0.105**
Intention become researcher	-	-	-0.135**	-	-	-
ICT necessary for researcher	0.135***	-	-	-	0.123***	-
Female	-0.081*	-0.366***	-	-	-0.070*	-
Human	0.114***	0.160***	-	0.106**	-0.106**	-
ICT in sec school	-	-	-	-	-	-
Parents HE graduates	-	-	-	-	-	-
Adj. R ²	0.078	0.184	0.068	0.058	0.099	0.080
F	23.16***		6.10***	5.32***	8.62***	7.12***

*p<.05

** p<.01

*** p<.001

^a Calculated using Proc Robustreg of SAS

^b Standardized regression coefficients

Figure 1. Explanatory model

Predictor variables		Dependent variables
<ul style="list-style-type: none"> -usefulness of computers -control of computers -anxiety -behavior expressing a negative attitude towards PC -academic self-perception - vocational or professional orientation -attitude towards science -intention to become a researcher -intention to become not a researcher -Scientific research needs ICT <p><i>Context:</i></p> <ul style="list-style-type: none"> -female (1) or male (0) (dummy variable) - domain of study (Humanities students (Human) = 1; others = 0) -ICT course in secondary school (ICT in secon =1; no course = 0) - at least one parent got higher education (= 1; parents no higher education = 0)		<p>ICT competences</p> <ul style="list-style-type: none"> -Maintenance of PC -Word -Spreadsheet (calculation, style change, work on graphs) -Database - Presentation program (work on data, presentation change) - Browser (technical use of browser, - information collection) -Communication <p>Frequency of ICT use</p> <ul style="list-style-type: none"> -Use of PC for study -Use of PC not for study - Use of ICT instruments for study - Use of ICT instruments not for study - Use of ICT programs for study - Use of ICT programs not for study

Highlights

- Construction of new instruments to measure basic ICT skills and frequency of ICT use.
- Explanatory model composed of TAM, appreciation of research, and context variables.
- Model fruitful to explain ICT skills, but not frequency of ICT use.
- Students' ICT skills better when control over PC, no PC anxiety, ICT needed by research.
- Frequency ICT use higher when ICT seen as useful, non-research oriented job, control over PC.