Remote Robotic Experimentation
An Evaluation of Intention to Use by High School Teachers in Cyprus

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Abstract: The Digital Agenda for Europe (2015) states that there will be 825,000 unfilled vacancies for Information and Communications Technology by 2020. This lack of IT professionals stems from the small number of students graduating in computer science. To retain more students in the field, teachers can use various educational technologies to explain difficult concepts. One of these educational technologies is remote robotic experimentation. The correlational study described in this paper utilizes the unified theory of acceptance and use of technology acceptance model to examine if performance expectancy, effort expectancy, social influence, and facilitating conditions can predict the intention of high school computer science teachers in Cyprus to use remote robotic experiments in their classes. Surveys, based on the UTAUT survey instrument, were collected from 90 high school computer science teachers in Cyprus, and a multiple regression analysis was applied to measure the correlations between the constructs and finally the model fit of the analysis. The results of the study show that if certain conditions are provided to the teachers then there is a higher probability that they will use remote robotic experimentation in their classes.

1 INTRODUCTION

In 2015, the Digital Agenda for Europe reported that there would be an estimated 825,000 unfilled vacancies for Information and Communications Technology (ICT) by 2020 (Digital Agenda for Europe, 2015). This lack of ICT professionals can be attributed to the small interest of high school students to follow a computer science degree, as evidenced by the decline in the number of students taking computing and ICT A-level examinations (The Royal Society, 2012). In addition, the increased number of students dropping out of computer science or changing majors has led to a reduced amount of graduates(Chen, 2015).

Even though considerable research efforts have been made for identifying the reasons behind the student' dropout from STEM-related fields of study, little research has been implemented on the conditions which can encourage younger students to pursue a STEM-related field of study (Wang, 2013).

Several methods have been introduced to help students better understand difficult concepts in computer science courses. Techniques such as problem-based learning (PBL) help by allowing students to self-learn using real life problems (Sangestani and Khatiban, 2013; Tsai and Chiang, 2013). One of the biggest constraints in the use of PBL is the cost of owning and maintaining equipment. Remote experimentation allows students to use equipment that is remotely accessed reducing costs. The use of remote robotics experiments during the implementation of the educational process is one of the factors which can potentially increase retention rates in STEM-related fields of study.

The aim of this paper is to contribute to this area of research by presenting the results of a study performed among high school computer science teachers in the country of Cyprus. The methodology applied in this study utilized questionnaires that measured the intention of high school teachers to use robotic experiments in their classes. The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, M. G. Morris, *et al.*, 2003) was employed as the basis of the study. The aim of this research effort was to identify underlying

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conditions which can predict the intention of high school teachers to use novel teaching techniques in their classes. The novel teaching technique introduced to the teachers in this study was remote robotic experimentation. RRE allows students to program robotic devices remotely providing hands-on experience. Robotic devices are deployed in a controlled environment and monitored through webcams. Students can access the robots and download code to them through a web interface and then observe the actions that the robot will perform. Several research studies have been conducted examining the development and use of remote robotic experiements (Osentoski *et al.*, 2012; Kulich *et al.*, 2013; Verbelen *et al.*, 2013; Casini *et al.*, 2014).

Teachers can provide students with a problem and then give access to a remote robot that is build based on the specifications of the problem. Students can then use a scheduling platform to reserve a timeslot to use the robot and then upload their code on the robot and observe the actions performed. This allows students to access the robot at any time of the day increasing the number of students that can experiment and relieves the teacher from having to sacrifice class time for students to experiment.

The rest of this paper is organised as follows: Section 2 will provide a brief description of various educational technologies used to enhance learning in computer science classes. Section 3 will then describe the theoretical framework used in this study and finally section 4 will present the results of the study. Finally, the paper will conclude with a brief analysis of the findings and future work.

2 RELATED WORK

The use of innovative educational technologies to enhance teaching and explain difficult concepts to students is a subject that has attracted a lot of research. This section presents three educational techniques used in teaching computer science concepts to students beginning with problem-based learning, remote experimentation and finally remote robotics experimentation.

2.1 Problem-based Learning

Problem-based learning (PBL) is an educational approach that allows students to take responsibility of their own learning process (O'Grady, 2012; Lykke *et al.*, 2015). Using PBL, teachers present students with a complex problem and then assign them to groups that are responsible for identifying the key issues and forming a solution to the problem through self-learning (Karantzas *et al.*, 2013). The five major characteristics of the PBL approach are: the statement of the problem, the definition of the problem in such a way so as to promote student learning, the process of self-directed learning by the students to solve the problem, the reflection of the students on their solutions to the problem, and the small groups assigned to the problem (Scott, 2014).

The most prominent application of PBL is medical education but in the past years computing has become the second most prominent application (Tsai and Chiang, 2013). PBL has been used in computing education extensively and has been shown to promote problem-solving skills, teamwork and motivation (Martinez *et al.*, 2014).

2.2 Remote Experimentation

One of the reasons that PBL is not widely used in schools can be attributed to the increased time required by the students to solve a particular problem (Kong Pak-Hin, 2014). Providing a problem to students and expecting them to self-direct their learning process while at the same time allowing time for interaction and collaboration between the students requires time. This time overhead has a negative impact in the educational process. In addition, PBL may require extra facilities such as equipment, space and personnel needed to achieve the required solutions to the problem (Ionescu *et al.*, 2013; Saad *et al.*, 2013).

Due to the aforementioned constraints in PBL, two new educational technologies have emerged allowing students to practice their problem-based activities outside of the classroom. These two technologies are virtual/simulated laboratories and remote experimentation laboratories (Abdulwahed and Nagy, 2013). Virtual labs allow students to use simulation software in order to complete educational tasks, reducing in this way the need for expensive equipment. Other benefits include the manipulation of time, allowing experiments that would normally take significant time to complete, to finish faster, and the removal of confusing details that do not influence the experimental process (de Jong, Linn and Zacharia, 2013; Merchant *et al.*, 2014). On the other hand, remote laboratories allow students to use real physical equipment remotely. The benefits of using remote labs include reductions in required equipment, and maintenance time, as well as availability on a 24/7 basis (Zubía and Gustavo, 2012). In addition, using real physical equipment allows students to receive realistic feedback during the implementation of the experimental process.

2.3 Remote Robotics Experimentation

During the past years, robotics research has grown exponentially and it is predicted that the robotics industry will significantly increase as well (Kulich *et al.*, 2013; Padir and Chernova, 2013). Robotics is used in introductory design and computer programming education in order to attract more students to study in STEM fields (Esposito, 2017). The biggest problem of using robots in education is the high cost of equipment, maintenance and availability of the robots. The development of a remote robotic laboratory could help in allowing students to perform PBL tasks using robots, while at the same time reducing equipment and maintenance costs, and providing constant access to the platform.

Using remote robotics laboratories allows students to follow the experimental process from any geographic area in the world, and have access to state-of-the-art equipment (Heradio *et al.*, 2016).

3 THEORETICAL FRAMEWORK

This research study aims to examine the intention of high school computer science teachers in Cyprus to use remote robotic experimentation in their curriculum. Examining user acceptance of a technology has been researched for several years and there are several frameworks available that can help identify the factors affecting acceptance. The theory of reasoned action (TRA), technology acceptance model (TAM), motivational model (MM), theory of planned behaviour (TPB) and the unified theory of acceptance and use of technology (UTAUT) (Oye, A.Iahad and Ab.Rahim, 2014). This study has adopted the UTAUT theoretical model in order to examine the intention of participants to use remote robotic experimentation during the educational process.

UTAUT utilizes four main constructs in examining intention behaviour (Venkatesh, M. G. Morris, *et al.*, 2003): performance expectancy, effort expectancy, social influence and facilitating conditions. In a study comparing various technology acceptance models, UTAUT has been found to predict more accurately intention of use (Venkatesh, M. G. Morris, *et al.*, 2003).

The first construct used in UTAUT is performance expectancy (PE). PE is a measure of the performance increase that users of the technology can expect if they adopt the technology. In this study PE would show how teachers expect remote robotic experimentation can increase their teaching performance in their classes.

Effort expectancy (EE) represents the expected effort that a user will expend to learn and use the new technology. The model in this study examines the thoughts of the users with relation to the effort that the teachers expect to put into learning how to use remote robotics experimentation and the effort that they will expend when teaching using the technology.

The third construct in UTAUT is social influence (SI). Social influence measures how susceptible users are to outside influences such as colleagues, managers or even close family and friends. The survey provided to the high school teachers is mostly based on the influence that the Ministry of Education has on the decision of the teachers to use remote robotic experimentation.

Finally, the last construct examined in UTAUT is facilitating conditions (FC). This variable examines the intention of someone to use a technology based on the existence of the conditions required for the technology to work. These facilities include the hardware, software, training and support channels that can help the adopter succeed in using the technology. In remote robotic experimentation the facilitating conditions include the robotic platforms, the servers and software required for the platform to work and the high availability of these resources. In additions the teachers would need to be trained and supported throughout the use of the platform. In the survey described in this paper we examined how important these facilitating conditions are for the high school teachers in order to adopt the use of remote robotic experimentation.

4 DATA COLLECTION & ANALYSIS

A questionnaire was distributed to all high school teachers in Cyprus, through the Cyprus High School Computer Science Teachers Association. The questionnaire used the UTAUT survey instrument that has already been validated in several research studies (Venkatesh, M. M. G. Morris, *et al.*, 2003; Li and Kishore, 2006; Thomas, Singh and Gaffar, 2013). The survey instrument evaluated the four main constructs identified in UTAUT, namely performance expectancy, effort expectancy, social influence and facilitating conditions. Out of approximately 400 registered high school computer science teachers we received 90 responses. Using G*Power analysis with a medium effect size (f = 0.15), error probability (a = 0.05) and a power of 0.80, the minimum required sample size is 85 participants.

The questionnaire was distributed to all high school teachers in Cyprus through an email invitation sent by the Cyprus High School Computer Science Teachers Association. In the email the teachers found a link to a Google forms questionnaire that explained the research and that no identifying information will be collected.

The research question was to check if performance expectancy, effort expectancy, social influence and facilitating conditions could significantly predict the intention of high school computer science teachers in Cyprus to use remote robotic experimentation. This evaluation was done using multiple regression analysis to determine if the four independent variables had a significant relationship to the dependent variable, namely behavioural intention.

4.1 Data Analysis

The data gathered from the questionnaires was based on a Likert-scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). The questions were grouped in five main groups representing the four independent variables, namely performance expectancy, effort expectancy, social influence, facilitating conditions, and the dependent variable which was behavioural intention. A multiple regression analysis was performed on the responses using the SPSS statistical software.

An exploratory factor analysis was initially performed on the data in order to validate the five constructs that were examined in the theoretical framework. The factor analysis correctly grouped together four of the five factors with an eigenvalue of more than 1.0. Performance expectancy, effort expectancy, facilitating conditions and behavioural intention were identified whereas social influence was not clearly identified in the pattern matrix.

Due to the low number of responses in the survey the study tested the validity of the sample using such tests as multicollinearity, normality, homoscedasticity and independence of residuals. All tests were within permissible parameters validating the survey data.

The regression analysis of the four independent variables in relation to the dependent variable is presented in table 1. The model as a whole was able to significantly predict behavioural intention, $F(4,85) = 11.417, p = .000, R^2 = .34$. The R^2 value indicates that the model can predict the intention of high school computer science teachers in Cyprus to use remote robotic experimentation in their classes with a total variability of 34.9%.

Table 1: Regression Analysis Summary for Predictor Variables.

Variable	B	SE B	β	T	p
PE	.191	.130	.164	1.467	.146
EE	.343	.131	.287	2.614	.011
SI	-.085	.118	-.094	-.721	.473
FC	.357	.131	.347	2.733	.008

Note. N = 90

4.1.1 Performance Expectancy

As previously mentioned, PE measures the expected performance increase that the high school teachers expect from using remote robotic experimentation. The analysis of the data shows that even though there is a positive correlation between PE and BI (.191) a p value that is greater than 0.05 indicates that PE is not a strong predictor of BI. Studies involving teachers that also use UTAUT have also shown that PE is not a significant predictor of behavioural intention (Chen and Chen, 2015).

4.1.2 Effort Expectancy

Effort expectancy measures the effort that the high school teachers expect to put into learning and teaching remote robotic experiments in their classrooms. EE was the second most significant predictor of behavioural intention with a positive slope (.343) and a p value of .011. This finding suggests that high school teachers in Cyprus would adopt remote robotic experimentation if the effort required to learn to use the technology and then apply it to their classroom is small. Further analysis of the data showed that the squared semi-partial coefficient (sr^2) for effort expectancy was .229 indicating that 22.9% of the variance of BI is based on effort expectancy. Several other studies also support the fact that effort expectancy can be a strong predictor of behavioural intention in teachers (Bhatiasevi, 2015; Sharon *et al.*, 2015; Tosuntas, Karadag and Orhan, 2015).

4.1.3 Social Influence

The third independent variable examined by the study is social influence. This variable examines the influence that people in the user environment have on the behavioural intention to use a technology. SI had a slightly negative slope (-.085) and a high p value

(.473) indicating that SI is not a predictor of BI. This trend regarding Information and Computing Technologies (ICT) seems to be justified by other literature (Escobar-Rodriguez, T., Carvajal-Trujillo, E., & Monge-Lozano, 2014; Oye, A.Iahad and Ab.Rahim, 2014). Social influence is considered to be the least significant predictor of behavioural intention.

4.1.4 Facilitating Conditions

The strongest predictor of behavioural intention in this study was facilitating conditions. Facilitating conditions are said to predict use behaviour (UB) in UTAUT rather than BI. Nevertheless, research has shown that even though FC is not directly associated with BI there is a relationship that has a strong positive correlation between FC and BI (Raman and Don, 2013; Bhatiasevi, 2015). In this study FC has a positive slope (.357) with a low p value (.008). The squared semi-partial coefficient (sr^2) was .239 indicating that 23.9% of the variation in behavioural intention was based on FC.

4.2 Model Analysis

The results of the survey study showed that teachers are more willing to adopt the remote robotics experimentation technique if the facilities are provided to them. This means that the teachers would want to have the hardware and software relating to remote robotic experiments available at all times as well as training and support for the use of the experiments.

The second strongest predictor of behavioural intention was effort expectancy; this means that teachers need to know that the use of remote robotic experimentation will take little effort to learn and use in the classroom. If the technology is hard to learn and takes too much time from the teacher to setup and deploy in the classroom then there is a high probability that they will not want to use it.

The last two constructs, namely performance expectancy and social influence, could not be considered predictors of behavioural intention for the use of remote robotic experiments.

Overall, the UTAUT model fit showed that it could predict the behavioural intention of high school computer science teachers in Cyprus to use remote robotics experimentation. The results of the study can be used to strengthen the conditions that teachers would like to see met before adopting remote robotic experiments. In this way, the curriculum makers can focus on making technology as easy as possible to learn and deploy, as well as on providing all necessary infrastructure in order to use and support remote robotic experimentation.

5 CONCLUSION AND FUTURE WORK

This research study aimed in identifying the intention of high school computer science teachers in Cyprus to use remote robotic experimentation in their classes. The results are very important for curriculum makers because it can help them understand what the teachers need in order to embrace this new technology. The theoretical framework was based on UTAUT, which uses four main constructs that can help predict behavioural intention. These four constructs are performance expectancy, effort expectancy, social influence and facilitating conditions.

The study showed that there are constructs such as facilitating conditions and effort expectancy which can increase the probability that high school teachers will use remote robotic experiments. The study also showed that performance expectancy and social influence had no effect in the intention to use the technology.

The results allow curriculum policy makers to identify appropriate ways in which to deliver a new curriculum based on robotics education, one that will have increased chances of being adopted by the teachers. Since the study showed that facilitating conditions is the biggest predictor of the intention of high school teachers to use remote robotics experimentation, policy makers will have to ensure that required facilities are already in place before the introduction of the technology to the teachers. This means that the hardware and software should be in place and operational, while a group of people will provide support to the teachers through the training and application stages of the educational process.

In addition to facilitating conditions, effort expectancy was also found to be a strong predictor of intention to use remote robotic experimentations. This means that policy makers will have to take measures in developing a curriculum that is easy to adopt and make the use of the remote experimentation platform as easy as possible for both teachers and students. If teachers find that the system is hard to learn or that the platform has several operational problems, then they will be reluctant to adopt it.

Future work includes the development of a remote robotic experimentation laboratory for high school computer science teachers in Cyprus. This laboratory will allow the implementation of Training of Trainers courses which will educate teachers in the use of remote RobotC experimentation and will increase their exposure to the educational technology.

Having a remote robotic laboratory available will also allow researchers to perform studies that will gauge the possible educational improvements of remote robotic experimentation over other educational approaches.

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