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ABSTRACT:
Nowadays, it is common to use computer simulations for learning and gaming. However, using robots in everyday learning is still limited to specific fields of study and professions due to the costly access to professional labs. In this study, we sought to compare team learning effectiveness between a remotely controlled robotic system via Skype and a computer simulation through a set of experiments. No significant differences were found between systems, so this study suggests that remotely controlled robotic systems via Skype can serve as a good alternative e-learning system for students to learn more realistic interactions with expensive equipment, which are not easily accessible with computer simulations.

Keywords: e-learning, robotic technologies, collaborative learning, shared team representation, psychological safety, learning outcomes.

Introduction

Rapid technological changes impact the educational field by enhancing the availability of education and knowledge through e-learning (El Gamal & Abd El Aziz, 2011; Arbaugh, 2004). E-learning has the potential benefit of spreading knowledge more efficiently and less expensive, regardless of time and location constraints (Brandon & Hollingshead, 1999; El Gamal & Abd El Aziz, 2011). Although many traditional courses have been converted online, people have recently started to explore the opportunities to develop complicated technological courses online. Computer simulation is a common approach to supplement technology access needs, despite the disadvantage of being lack of real interaction with specific technologies such as robots. For engineering courses, students often need to gain access to expensive robots or rare equipment; however, many constraints, especially costly expenses and distance, prevent students from accessing these labs. Indeed, robots play an increasingly important role in our lives, such as working on dangerous rescues and complicated surgery jobs where people normally work in teams to deal with sophisticated operations. Instead of providing students with nonrealistic learning experiences with common computer simulation system, we can use a remotely controlled robotic system to achieve better or equivalent learning outcomes in a more cost-effective way, compared with commonly used computer simulation systems. This is therefore the main focus for this study.

When technology is used during e-learning, a question may be raised regarding the potential differences among types of technology. It has been found that acceptance of technology has a positive impact on learning perception among students, which is influenced by the personal perception of benefits and the utilization of technological tools (Mathur, 2011). Despite the disadvantages, prior collaborative learning studies show that e-learning enhances collaboration and communication among participating groups, fosters and enables independence among the students, and increases their responsibility (Brandon & Hollingshead, 1999; Arbaugh, 2004).While teams are involved in the learning process, the psychological and mental aspects of group perception such as the psychological sense of safety with other team members and shared knowledge of the mere task are also relevant for measuring the effectiveness of e-learning (Van Ginkel, 2007; Schepers et al., 2008). Although advanced technology is now common and widespread, it is important to explore and understand the way technology and different technological tools may influence the studying process, especially regarding aspects of personal perceptions of technology and the team. In this study, we designed and implemented two different e-learning technologies to explore student learning effectiveness on robotics: (1) Remotely controlled robotic system through Skype: Robotic equipment can be used to practice experiments in a remote lab, and (2) Computer simulation: a computerized simulation software is employed to practice robotics operations online.

In the next section, we introduce the background of this research. We then propose a set of hypotheses to examine the effects of team psychological safety and shared task representations on perceived technology usefulness, and furthermore on team learning outcomes. Following a description of the study design, we briefly present our data results, and lastly, discuss the study findings and implications.

Related Work

Currently, robots are playing an increasingly critical role in manufacturing assembly lines, medical procedures, underwater search and rescue, and space exploration. Advances in robotics have opened up new arenas for applications in education. According to Turner (2009) using robots for educational purposes can involve a “mix of theoretical and practical experience,” which is ideal in teaching mathematics, scientific principles, design & technology, and computer programming. An environment based on physical elements may help students develop stronger affective bonds with it (Piaget, 1981), and increase learners’ motivations and make learning a more enjoyable experience (Wei et al., 2011). As a matter of fact, robot experimentation may be implemented through Skype technology, which allows remote actions to be executed and controlled them while monitoring online, via a personal computer (Cabibihan et al., 2009; Hussain et al., 2011).

Computer simulation refers to the imitation of a natural or artificial system or processes (De Jong et al., 1998). Its use in education has the potential to generate higher learning outcomes (Akpan, 2001). Computer simulations have become an integral part of many science curricula. Simulations may also encourage students to participate actively in learning activities, and enhance their thinking in science (Duffy & Jonassen, 1992).

As has been stated above, computerized environments have become very common, and both young and older students are used to a variety of simulations and virtual realities through their previous experience with computer games, training simulators and interactive websites (Mennecke, 2008). However, the use of robots in everyday learning experiences is still limited to specific fields of occupation or studying, such as those stated above. The possible differences between software simulation and real robotic tools can emerge for reasons of trust and suspiciousness toward robots, mainly because of the human antecedence of expected failure of the robot (Billings et al., 2012). An additional relevant issue is the safety of the robots while they interact with people in work teams (Kamide et al., 2012). The main question that arises is whether people consider working with robots the same as working with computerized simulations or not. This question may be asked regarding the perception of learning and usefulness concerning both terms of technological methods (robots vs. simulation). Moreover, it is important to understand team perception aspects such as psychological safety in the team and shared task representation for deploying complicated.

Research Hypothesis

In this study, we seek to understand the role of team perception of psychological safety and shared task representations on perceived learning effectiveness, by setting up an experiment with two alternative e-learning technologies for students to learn robotics technologies. We hypothesize both psychological safety and shared task representations have a positive effect on perceived usefulness with two e-learning systems, which in turn significantly impacts student learning effectiveness. We also posit that team psychological safety has a positive impact on student learning effectiveness.

In the technology acceptance model, perceived usefulness (PU) is defined as “the degree of which a person believes that using a particular system would enhance his or her performance” (Davis, 1989). The perception of learning (PL) presents a self-reported learning effectiveness that a person has experienced through particular learning processes. This construct is used in a variety of aspects in educational fields, which can refer to learning processes with classroom peers and collaboration (Alavi, 1994) and to perceived learning of technological changed adoption or acceptance (Arbaugh, 2004). Schepers et al. (2008) found that the duration of usage of technology is relevant to perceptions of learning. Thus, we posit that when users perceive more technology usefulness, they can perceive more learning, regardless of the technological tool:

H1: Perceived usefulness will be positively associated with perceived learning.

Prior research demonstrates that team work elevates perceived learning (Alavi, 1994). Several aspects of team work such as interpersonal trust, supportive judgment and good conditions contribute to team work, while enhancing psychological safety of the team member. Psychological safety (PS) is defined as the “sense of interpersonal trust and being valued in a work team” (Schepers et al., 2008). Good levels of PS are achieved when a person is not in fear of negative consequences or of jeopardizing one’s self image, status or career (Kahn, 1990). Psychological safety is related to perceived learning and performance (Edmondson, 1999), and it influences PU (Shcepers et al., 2008). So we also suggest that:

H2: Psychological safety will be positively associated with perceived learning.

According to the expected association between perceived usefulness and perceived learning, it may be assumed that the former may have a role as a mediator amid psychological safety and PL, so PU may explain part of the covariance of the two other factors. We thus suggest this mediation:

H3: Psychological safety will be positively associated with perceived usefulness.

In addition to interpersonal psychological factors, cognitive factors such as representation of the task can also influence learning processes. Working in teams, *shared task representation* (STR) refers to the understanding of the task by all the members together, which is achieved by interchanging knowledge between them. STR itself was found to be positively related with psychological safety, and the association amid them was explained by the fact that PS regarding the teammates reduces fear of rejection, thus allowing the interchange of knowledge (Van Ginkel, 2007), which results in better information utilization and higher team performance (Hsu et al., 2011). It is likely that when users are more willing to share or interchange ideas about different aspects of tasks, they are more likely to perceive more usefulness about the technology, thus improving overall performance as a team. Therefore, regarding shared task representation, we expect that:

H4: Shared task representation will be positively associated with perceived usefulness.

H5: Shared task representation will positively impact perceived learning.

As stated above, computer simulation and remotely controlled robotics may differ in some aspects such as the previous experience of a person has with any of them. However, in other aspects such as quality of group learning, independent thinking and innovation, we do not expect the two tools to differ. The abundance of opportunities and advantages that these two technologies can raise suggests that we explore the similarity amid the two, along with the factors that are assumed to influence learning (psychological safety, shared task representation, and perceived usefulness), and especially, perceived learning itself.

H6: computer simulation participants will show (almost) an equal level of perceived learning compared to robotic tool participants.

Research Method

Participants

The sample was composed of 208 undergraduate engineering students ranging from freshman to sophomores. They were randomly assigned to either remotely controlled robotic or computer simulation trials. The average age of the participants was 25.05 (SD=3.62); 69% were male and 31% were female. The majority (73%) of participants had 5 or more years of Internet experience.

Measures

The research included demographic and background questions, and also included several questionnaires in order to measure the experimental factors. All key constructs were adapted from existing validated research.

Experimental Procedure

We recruited 208 engineering students at a university in Israel. The incentive was a coupon for free coffee and cake. The experiment involved pairs of students: one operated the system, and the other acted as an advisor. The experiment consisted of the following steps. First, the researchers explained the experimental procedures to students, and asked them to sign on their consent forms. Each student received a unique ID for the experiment. The pairs were then randomly assigned to either the remotely controlled robotic tool or the computer simulation to complete a series of tasks of object rotation and movement (under both terms). After completing the required tasks, participants were asked to fill in a post questionnaire.

Summarized Data Analysis Results

All data obtained were transferred to SPSS in order to examine the proposed hypotheses. We performed a Varimax method factor analysis to all of the factors that were included in the model, and all factor loading reached a satisfying level. The Cronbach's alpha values of all four constructs (TR, PS, PU and PL) were above .84. All four factors were positively correlated with one another ($p<.01$).

Although Pearson correlations between all factors were found, we performed a set of hierarchical linear regressions in order to verify our first five hypotheses. In all of them, we entered in the first step (Enter method) four control variables: age, gender, experience with the internet and tool type (robot versus simulation). The data analysis results indicate that H1, H2, H3, H4 and H5 were significantly supported ($p<.01$).

In order to explore the differences between the two technological tools, robots and computer simulation, we performed a series of T tests, one for each of four constructs (PL, PU, STR, and PS). No difference was found between the two types of e-learning tools, the robotic and the simulation in the PL, meaning that participants who experienced the robotic tool and those who experienced computer simulation do not differ, at a confidence level of 95%. So H6 was also proved significant at $p<.01$.

Discussions

This study compares two educational e-learning technologies, which can be used among engineering students who study robotic subjects in their curriculum. Although no significant differences were found between two e-learning systems, compared to popularly used computer simulation system, this study demonstrates the possibility to access remote expensive labs to practice necessary skills though Skype. Moreover, integrating group work with Skype is a normal way of working, and has some advantages over simulation tools that are more widely used at the individual level. A further major contribution of this paper is the indication that shared task representation is positively related to perceived usefulness. These findings emphasize the importance of enhancing and promoting the sharing of knowledge and insights regarding the team's task for designing collaborative e-learning systems.

In comparison to a computer simulation system, the robot environment can enable a sense of actually dealing with "real things," and provide a similar degree of shared task representation, perceived usefulness and learning. Indeed, using robots through Skype as an educational tool for teams and groups can elaborate creativity and innovation, and is expected to promote collaboration and better communication between the members, while increasing learning and task perception, and thus might also improve team performance (Hsu et al., 2011). Using the robot tool remotely has the advantages of spreading knowledge across nations and beyond boundaries. This accessibility plays a key role in using this remote robotic tool for training and education purposes, while preserving the feeling of dealing with real high technological equipment, without compromising or jeopardizing the outcomes.

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