

Impact of Collaborative Learning on Student Perception of Virtual Computer Laboratories

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Abstract— In the last decade, virtual computer laboratories have been successfully used to provide students with hands-on experimentation in information technology fields in a cost effective and secure manner. In this paper, we study the effect of collaborative learning on student perception and acceptance of virtual computing as a learning medium. Virtual computing is a relatively new technology and can be intimidating for students at times with limited information technology background. Students can feel overwhelmed as they follow voluminous and tedious step-by-step information technology activities that are not very familiar to them. Collaborative learning can help to alleviate such problems and enhance the student experience of using a virtual computer laboratory in different ways. To investigate the effect of collaborative work on student experience in virtual computer laboratories and their acceptance of this new technology, we conducted empirical studies where two groups of students (with technology and non-technology backgrounds) performed two types of hands-on activities. These types were individual and collaborative in nature and were conducted in a virtual computer laboratory. Then, we compared the experiences of the two groups across the types of hands-on exercises. The preliminary findings show that novice students benefited more from collaborative learning when compared to more experienced, and probably more technologically competent, students.

Keywords—*virtual computing; technology acceptance model; collaborative learning; group work.*

I. INTRODUCTION

Today, Virtual Computer Laboratories (VCLs) are frequently used in engineering [1], computer science [2], and information security programs [3] as a new means of providing students with hands-on experimentation dealing with key concepts. A VCL consists of virtual machines (VMs), which are software emulations of actual operating systems running on a computer. Using a hypervisor, a single server can host multiple VMs. Being software emulations, properly installed VMs are secure in a way that the physical server and its

associated systems cannot be corrupted or changed by students using VMs running on it. Therefore, students can experiment with complex and high risk operations without any fear of system damage or policy violations.

VCLs are being used to enhance student learning in various ways. In fields, such as information security, VCLs are used to give students the skills necessary in the corporate world where a broad range of information technologies exist [2]. In engineering fields, VCLs provide students with remote access to specialty software packages that are frequently used in such classes [1]. In asynchronous distance learning, VCLs enable students to perform self-paced hands-on activities remotely [4, 5]. Overall, VCLs have reduced the cost of establishing and maintaining specialized computer laboratories, made campus computing resources available to students anywhere and at any time, and have provided flexible and secure computing environments for many institutions.

Like many new educational technologies, learning how to use a VCL can be a challenging task for some students. The literature on virtual learning environments [6, 7] report that frustration, confusion, and stress associated with using a new technology are detrimental factors affecting students' acceptance of these technologies. Previously, several research papers [7-10] utilized the technology acceptance model (TAM) [11] to study the acceptance of educational technologies by students. The common findings of this previous research indicate that the more students perceive a system useful for their purpose and easy to use, the more likely they accept the system for future use.

Although TAM has not previously been used to study the acceptance of VCLs, earlier applications of TAM to other virtual learning environments are relevant to the research in this paper. For example, Chung and Vogel [12] explored the TAM in the context of collaborative technologies for e-learning. Their work confirmed that the TAM is a useful tool for examining the effectiveness of technologies utilized in e-

learning. More importantly, they identified that peer influence is an important determinant in the acceptance of e-learning technologies, which is certainly relevant for collaborative laboratory assignments. Sun et al. (2008) [13] explored e-learner satisfaction and the factors that influence it. One of the key determinants identified in their work was "flexibility". Although the format of e-learning was not a distance-based learning scenario in this study, the self-paced nature of the laboratory assignments utilized was able to approximate this flexibility in the laboratory classroom environment. Raman et al. [14] investigated various attributes of virtual laboratories and reported that perceived ease of use significantly predicted the adoption of virtual laboratories by students. Konak, et al. [15] reported that students perceived a VCL as much more useful for their learning when they performed activities in groups. Hsieh and Cho [16] contrasted instructor-student interactive and self-paced e-learning tools using a model based on TAM, and they reported that instructor-student interactive e-learning tools led to higher perceived usefulness.

This work-in-progress paper investigates the impact of collaborative work on the acceptance of a VCL by students through an empirical study. Our main research hypothesis is that collaborative learning activities may lead to a higher level of acceptance of VCLs compared to individual ones utilizing VCLs. In addition, the paper investigates the effect of students' information technology background on the relationship between technology acceptance and collaborative work for the first time in the literature. The preliminary findings of the outlined research may inform educators about the benefits collaborative learning strategies while introducing a new educational technology to students.

II. RESEARCH METHODOLOGY

A. Experimental Setup of the Empirical Study

To investigate the effect of collaborative work on student perception and acceptance of VCLs, an empirical study was conducted in the Collaborative Virtual Computer Laboratory (CVCLAB) [4] where two groups of students performed two versions of a computer networking exercise. The CVCLAB is a VCL specially designed to support collaborative hands-on learning in information security, computer networking, and high level computer programming courses [4, 17]. The exercise included introductory level computer networking tasks such as discovering and configuring the TCP/IP settings of computers, testing the connection among computers, messaging between computers, sharing files and folders over a network, and configuring network file permissions. The step-by-step instructions of the exercise were also provided to students as hard copies. The detailed steps of the exercise can be found in [18].

One version of the exercise allowed for collaborative work (C) and the other involved individual work (I). In both versions of the exercise, students performed the same tasks and were introduced to the exact same content; but, students in the collaborative version had to work together for the successful completion of the activity.

In addition, the participating students were recruited from two different groups: information technology programs and

non-technology related programs such as business and social sciences. All participants were first-year students who used the CVCLAB for the first time during the exercise. No prior training on the use of the CVCLAB was given to the students, but they were provided with the step-by-step instructions about how to use the CVCLAB. Based on the participants' major (technology (T) or non-technology (NT)) and the version of the exercise that they performed (Collaborative (C) or Individual (I)), the empirical study was conducted for the following four groups.

- Group T-C: Technology students who performed the collaborative version ($n=59$).
- Group T-I: Technology students who performed the individual version ($n=35$).
- Group NT-C: Non-technology students who performed the collaborative version ($n=46$).
- Group NT-I: Non-technology students who performed the individual version ($n=47$).

Students were categorized as belonging to the technology or non-technology group based solely on their major. This assumption may not hold for all students because some students in non-technology majors can have advanced information technology skills. This is a limitation of the research. It should be noted that students in some initial work were grouped based on their self-reported information technology efficacy. However, self-efficacy turned out to be an unreliable construct to form the groups; and therefore, it was not used to determine the groups in this study. Students were assigned to individual or collaborative work groups randomly.

B. Data Collection Instrument

After completing the exercise, the students filled out a questionnaire to evaluate their experiences with the CVCLAB and their acceptance of the CVCLAB as a learning environment. All questions used a five-point Likert scale from strongly agree (1) to strongly disagree (5).

The first group of questions intended to measure students' experiences and satisfaction with the CVCLAB in several constructs as follows:

- Interest (INT): the extent to which the students' interest in VCLs was increased (3 Questions-Cronbach's Alpha=0.907)
- Satisfaction (SAT): how much the students were satisfied with their experience of using the CVCLAB (3 Questions-Cronbach's Alpha=0.895).
- Achievement (ACH): the degree that the students felt accomplished because of using the CVCLAB (3 Questions-Cronbach's Alpha=0.809).
- Enjoyment (ENJ): how much the students enjoyed interacting with the CVCLAB (3 Questions-Cronbach's Alpha=0.932).

Additional questions were adopted from TAM [11] to measure the following constructs:

- Perceived Usefulness (USE): the degree to which the students perceived that the use of CVCLAB would be beneficial for their learning performance (3 Questions-Cronbach's Alpha=0.880).
- Perceived Ease of Use (EOU): the degree to which the students believed that using the CVCLAB is straight forward (3 Questions-Cronbach's Alpha=0.883).
- Attitude towards using (ATU): (3 Questions-Cronbach's Alpha=0.890).
- Behavioral intention of future use (IFU): (3 Questions-Cronbach's Alpha=0.915).

C. Comparing the Groups

Fig. 1 illustrates the construct means for the four groups. Clearly, the technology students (T) reported much more positive experiences and a higher level of acceptance of the CVCLAB than the non-technology students (NT) did, regardless of whether they performed the activity individually (group T-I) or collaboratively (group T-C). All construct means across groups T and NT were statistically different with a significance level of $p < 0.001$ in t -tests. For the technology students, collaborative work did not have any statistically significant impact on either the experience-based constructs or the TAM constructs used in this research. All construct means across groups T-C and T-I were not statistically different (with $p > 0.1$ in all t -tests). On the other hand, collaborative work made a significant impact on the experience and acceptance of the CVCLAB by the non-technology students. As seen in Fig. 1, the non-technology students reported better experience and satisfaction with CVCLAB and accepted it more as a viable technology solution for their purpose when they performed the activity in groups. For all constructs, the means between groups NT-C and NT-I were statistically different with $p < 0.018$ (the largest p -value observed for INT in t -tests).

In particular, the difference in the means of EOU between groups NT-C and NT-I was quite notable. Surprisingly, non-technology students found the CVCLAB much easier to use when they performed the collaborative version of the exercise.

III. DISCUSSIONS OF THE FINDINGS AND LIMITATIONS OF THE RESEARCH

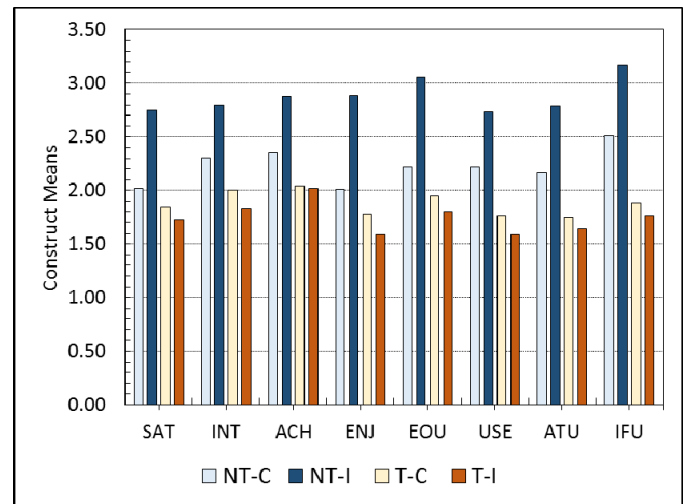
In this paper, the findings support the hypothesis that collaborative work can increase the acceptance of VCLs and improve overall learning experiences for students who have limited information technology background. The findings also show that technology students (T) have a significantly higher acceptance of VCL than non-technology students (NT). This outcome should be expected to some degree because such VCL technology is more familiar for the technology students that participated in this empirical study. Although no statistical difference was observed between groups T-C and T-I, this result should not be interpreted as collaborative work having no impact on learning for advanced students. Note that the research in this paper focused on technology acceptance and the experiences of students rather than on their learning specific concepts. Earlier research on computer-based learning overwhelmingly reports the benefits of collaborative work [19, 20]. In addition, benefits of collaborative learning in VCL are

demonstrated in earlier research [15, 21]. However, the effect of collaborative work on the acceptance of educational technology has not been studied before. Therefore, this finding of the paper is a unique contribution to the literature.

Mastering the use of a VCL can be difficult for some students. Frustration and confusion with a new technology usually lead to negative experiences for students in computer-based learning environments [6]. Stress associated with an unknown technology use and dissatisfaction towards the technology itself are among some negative factors affecting students utilizing virtual learning environments [7]. It is clear that if students develop a negative attitude towards an educational technology, then learning stands little chance of being enhanced through its usage and application.

A limitation of the research is that only a single exercise, which would be more familiar for technology students, but challenging for some non-technology students, was used. The ratings represented the snapshot of students' perceptions about the CVCLAB, and their perception could be affected by the exercise that the participants performed. Therefore, the empirical study could be repeated with multiple exercises with varying degree of difficulty.

Fig. 1. Comparisons of the Construct Means across the Student Groups (NT: Non-technology students, T: Technology students, C: Collaborative work, and I: Individual work).



IV. CONCLUSIONS AND FURTHER RESEARCH

The research in this paper studied the relationship between technology background of students and their acceptance of a virtual computer laboratory (VCL). In addition, the effect of collaborative work on the experience with and acceptance of this technology were analyzed. The findings support the hypothesis that collaborative work can improve a non-technology oriented student's acceptance of VCL technology. Although the acceptance of technology has been previously investigated in an educational context, the research outlined in this paper is the first to report the impact of collaborative work on the acceptance of technology.

Further data analysis is required to understand the relationships between the constructs used in this paper.

Current research activities involve developing and validating the research model using structure equation modeling.

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