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Examining the Impact of Learning Management Systems in Computer Programming Courses

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Examining the Impact of Learning Management Systems in Computer Programming Courses

By

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We hereby certify that this dissertation, submitted by Mohammed Naif M. Alatawi, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

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An Abstract of a Dissertation Submitted to Nova Southeastern University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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The development of software and communication technologies in education has led the majority of universities worldwide to integrate the functions of Learning Management Systems (LMSs) into their learning environments. LMSs offers several features that encourage their use by universities and other educational institutions, such as unlimited access to course content, easy tracking of learners' progress and performance, and reduced costs in terms of both money and time. Most existing LMS studies have been focused on experienced LMS users who are familiar with its functions, with little consideration given to new users. Furthermore, although previous researchers have identified various means of enhancing the effectiveness of LMS use, no consensus has yet been reached on which of these features most successfully improve the learning outcomes of new learners enrolled in programming courses.

The purpose of this study, therefore, was to examine the usability of particular LMS features and their impact on learning outcomes for freshman students enrolled in programming courses. Through the Virtual Programming Lab (VPL) and discussion forums, particular LMS features have been considered. For this study, a quantitative quasi-experimental design was employed, including experimental and control groups of new students enrolled in an introductory programming course that involved different LMS features. These features have been considered in the place of treatment in this experiment, in which the level of difference between participants in the two groups was compared.

This study involved two main dependent variables: LMS features' usability and learning achievement. For the first dependent variable, LMS usability, the participants completed a survey, based on the components of Shackel's usability model (1991), to evaluate the effectiveness of the LMS features' usability. Four constructs underpin this model: effectiveness, learnability, flexibility, and attitude. For the second dependent variable, learning achievement, the final grade was used to measure the impact of these two LMS features on learning achievement between the two groups.

The results revealed significance differences related to LMS features' usability and learning achievement between the experimental group and the control group. Participants in the experimental group reported greater LMS usability than did those in the control group, and overall course scores indicated improved learning performance in members of the experimental group who applied the VPL and discussion forms features of programming courses.

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Chapter 1

Introduction

Background

During the past decade, information technology (IT) has made a number of advances that have significantly benefited the field of education, perhaps most notably via integrating the LMS into the education sector (Lasrado, 2009). As one of today's most rapidly developing technologies, LMSs see wide use in educational institutions the world over and, like other types of software, are available in either free and open-source or commercial versions (Al-Busaidi & Al-Shihi, 2010).

An LMS, sometimes also called a learning platform, comprises a broad slate of subsystems designed to help instructors and students alike as they use online learning services (Paulsen, 2002). Recognizing the importance of this learning platform, universities around the world are modifying their strategies by adopting technologies that they believe will help them achieve their goals in this age of ready information (Alharbi & Drew, 2014). Indeed, the adoption of such information systems does much to advance the collaborative classroom, opening a new frontier of pedagogy (Clapp & Swenson, 2013).

Alassaf, Harfoushi, Obiedat, and Hammouri (2014) defined LMSs as education software applications that allow both instructors and learners to complete a range of tasks, including managing student documents, monitoring student activities, and administering exams, quizzes, and assignments. Furthermore, institutions can use LMSs to organize training programs, control course content, facilitate online communication between instructors and learners, and manage

learning progress events. Accordingly, their benefits and functions make them highly important applications for any educational institution.

However, according to Chughtai, Zhang, and Craig (2015), the user experience (UX) of LMSs is a serious cause for concern because a good level of usability can ensure that learners will use the LMS's features more effectively. Moreover, a consideration of learners' attitudes toward LMSs and the use of their experience in the development process is key to reducing the negative impact of LMS use during the learning procedure. This is because the main goal of using any LMS is to find an effective learning environment that supports learners to achieve their learning outcomes effectively and easily (Chaffar & Frasson, 2004). Furthermore, the rapid growth in the variety of online programs in higher education has spurred researchers and stakeholders to identify dynamic LMS features that can deliver in particular courses considered challenging for learners, such as computer science and healthcare (Azevedo & Feyzi-Behnagh, 2010). Accordingly, the main contribution of this study is an examination of the usability of LMS features and their influence on students' learning outcomes in programming courses.

Problem Statement

The existing literature is focused on experienced LMS users, with comparatively little attention paid to newcomers (i.e., freshman-level university students). Furthermore, although previous researchers have identified various ways of enhancing the effectiveness of LMS use, no consensus has yet been reached regarding which of these features most successfully improves learning outcomes for new learners enrolled in programming courses.

However, users' experience levels in using LMSs play a significant role in determining the degree to which the desired benefits are realized. Based on this factor, Al Hamad (2016) evaluated students' perceptions of LMS implementation based on use of the Moodle platform at Fujairah College, United Arab Emirates. Examining a population comprising a small group of

students with strong computer skills and experience of using an LMS, the researcher found that a positive perception of such use corresponded to an existing high level of technological skill among the participants.

Moreover, when new learners struggle to understand the content of a course, they are less likely to use the LMS effectively, or they show a negative response toward it. For instance, Rahman et al. (2010) adopted Shackel's usability model (1991) and its four principles—effectiveness, learnability, flexibility, and attitude—while seeking to gauge the effectiveness of the Open University Malaysia (OUM) LMS using the following four measures: ease of mastery, error tolerance, speed, and quality. The authors evaluated the effectiveness of the LMS used by learners enrolled in different academic courses with varying levels of difficulty, before randomly selecting students to complete a survey. Their findings revealed that new learners were negatively affected by an LMS when using the system for the first time in their courses (Rahman et al., 2010).

Nevertheless, a few researchers have evaluated the usability of LMS features for freshman students in challenging courses. Alhazbi (2016), for example, investigated the effects of students' use of LMS features as part of programming courses, hoping to increase levels of engagement and motivation among those taking introductory courses in this area at Qatar University. Although the author created an LMS environment designed to support students' collaborative learning by increasing levels of interaction between them and instructors, the latter faced challenges when they sought to use class activities to involve learners in programming courses during the semester. The findings indicated that students had a low level of the knowledge required to use certain LMS features; in particular, learners in these courses needed continuous guidance and support, such as communication tools intended to allow them to express their thoughts about class topics through LMS discussion forums (Alhazbi, 2016).

Furthermore, the VPL tool is one of the most important tools that could be integrated to LMSs in programming courses to support learners. For instance, Kaunang (2016) examined students' perceptions of a VPL tool that was integrated with an LMS at the University of Sam Ratulangi. The aim of this study was to reveal the weaknesses and strengths of VPL tools when used for teaching and delivering online programming classes in an engineering department in the academic year 2015–16. In his methodology, the author designed an online course for an electrical engineering program, making it available to students through the Moodle LMS portal. For the final evaluation, he conducted a survey that was focused on the use of VPL activities with Moodle LMS to complete the programming assignments and evaluate the coding exercise. The results showed that, in general, students had a strong VPL in most respects, but the author found a degree of weakness in students using VPL as a coding editor. In addition, he noted that some of the participants' feedback, in the section on VPL questions, was negative in terms of VPL availability.

What is more, no previous studies have successfully demonstrated exactly which LMS features are most useful for improving students' learning outcomes. Mwalumbwe and Mtebe (2017), for example, evaluated student performance at Tanzania's Mbeya University of Science and Technology (MUST) using the Moodle LMS. The researchers found no significant enhancing effect associated with a number of factors related to LMS use, including frequency of access, length of time spent on the platform, and quantity of materials downloaded. However, they did find a notable effect pertaining to other factors associated with LMS use, such as level of class interaction and engagement in discussion posts and course exercises.

Additionally, in an empirical study of the effectiveness of learning enhanced by LMS technology, Chowdhry, Sieler, and Alwis (2014) investigated the relationship between LMS features and students' academic performance. They compared student data for the 2013–14

academic year at Edinburgh Napier University, Scotland, using three different models to inform their analyses of students' final grades and levels of access to LMS features. The authors concluded that student access to material features did not directly affect academic performance in the Low Module (LM); however, they did recommend that future researchers compare constant factors between models to evaluate different LMSs. Moreover, they suggested that scholars investigate LMS access for specific activities with a view to evaluating student performance, which would allow them to identify LMSs that are more and less effective, with the ultimate goal of improving the student learning process (Chowdhry et al., 2014).

The studies described thus far reveal a lack of research in which efforts are made to evaluate the usability of LMS features in terms of impact on effective learning outcomes for freshman students enrolled in programming courses at higher education institutions. In fact, most studies have been focused on LMS features' usability in general terms and among users with a high LMS skills level (Alhazbi, 2016). Furthermore, no agreement has yet been reached regarding which LMS features most successfully improve learning outcomes in challenging courses (Rahman et al., 2010).

Dissertation Goal

The goal of this study was to evaluate the usability of LMS for freshman-level students who employ VPL and discussion forum features and its impact on their learning outcomes in programming courses. Whereas previous researchers have investigated the effects of LMS features in general terms, the aim here was to examine a specific combination of LMS features to determine which ones are likely to enhance learning environment outcomes for new learners enrolled in programming courses. Accordingly, the focus was on those features previously identified by researchers as most important for the delivery of such courses.

Research Questions

RQ1: What differences exist in LMS usability between freshman students who are using, or not using, LMS features (VPL and discussion forum) in programming courses?

RQ2: What differences exist in learning achievement between freshman students who are using, or not using, LMS features (VPL and discussion forum) in programming courses?

Hypothesis

Hypothesis 1: There are significance differences in LMS usability between freshman students who are using, or not using, LMS features (VPL and discussion forum) in programming courses.

Hypothesis 2: There are significance differences in learning achievement between freshman students who are using, or not using, LMS features (VPL and discussion forum) in programming courses.

Relevance and Significance

The significance of this study was threefold. First, the findings added to the body of knowledge related to LMS research by evaluating the usability of users' experience and LMS functions that may increase the efficiency of learning environments in difficult courses. Second, gaining mastery over the learning process, especially for new students, could increase the quality of university education programs' outcomes. Thus, universities around the world could tailor LMS features to their students' needs, easing new starts' transitions into challenging courses. In such an environment, LMS use can motivate and support learners to increase their own level of knowledge.

Barriers and Issues

The aim of this study was to investigate which features influence the effectiveness of LMS use, with a view to improving students' levels of academic achievement in difficult courses and

enhancing their outcomes in said courses. To this end, the target population was freshmen majoring in computer science; thus the findings are not generalizable to students of different majors or attending any college. Furthermore, students' ability to use LMSs could be limited by their varying levels of computer skills and different technological backgrounds.

Definition of Terms

Effectiveness – Defined as users' performance in the completion of systems tasks within some environments; it can be measured by characteristics of interaction, such as time and errors (Rahman, Ghazali, & Ismail, 2010; Alabbadi, M. M., 2010).

Flexibility – Defined as the adaptation to change in tasks and environments that can be more convenient for specific design (Rahman et al., 2010; Alabbadi, M. M., 2010).

Learnability – Defined as the level of users' ability to learn and complete systems tasks and learn the system's details, whether or not given training (Rahman et al., 2010; Alabbadi, M. M., 2010).

Usability– Defined as the degree to which the system can be used to achieve a specific goal by specific users with efficiency, effectiveness, and satisfaction in a certain task of use (Bevan, Carter, Earthy, Geis, & Harker, 2016).

Users' Attitude – Defined as users' satisfaction with the system, whether they continue using the system or improve their use of the system in terms of discomfort, tiredness, and personal effort (Rahman et al., 2010; Alabbadi, M. M., 2010).

List of Acronyms

IT – Information Technology

LMS – Learning Management System

VPL – Virtual Programming Lab

Summary

In Chapter One of this study, the following research areas are discussed: problem statement, study goals, research questions, significance, barriers and issues, definition of terms, and list of acronyms. The existing literature is focused on experienced LMS users, with little attention paid to freshman-level university students, and although previous researchers have identified several ways of enhancing the effectiveness of LMS use, no consensus has yet been reached regarding which LMS features most successfully improve learning outcomes for new enrollees in programming courses. The main goal of this study was thus to examine the impact of LMSs' usability on such outcomes for freshman-level students who employ particular LMS features in said courses. A specific combination of LMS features was also examined to determine which ones enhance learning environment outcomes for new learners enrolled in courses in which VPL and discussion forum features are applied. Chapter One also features an introduction to the research study's significance, barriers, and issues. Finally, this chapter includes a list of definitions of key terms for the reader to understand.

Chapter 2

Review of the Literature

Overview

In this study, the literature review is focused on whether the effective usability of certain LMS features can improve a freshman's learning performance in challenging courses. Specifically, the underpinning strategy is the investigation of a unique population—in this case, freshman students or novice learners in programming courses. The purpose of combining these features is to enable a better understanding of how LMS tools could effectively be used to improve freshmen's learning performance in said courses. This chapter will begin with the theoretical foundation of the study, followed by a review of the previous literature and identification of gaps, an analysis of the research methods used, and finishing with a synthesis of the literature.

Theoretical Foundation

The usability has multi-dimension constructs that can be evaluated from various perspectives. Moreover, the usability concept can be determined by the user experience (UX), the products (systems), environments, and tasks. The examination of any software use's effectiveness is one of the usability perspectives. From this point, we can clearly understand that the usability factor has a theoretical principle, based on the human-computer-interaction (HCI) field (Jeng, 2005). Usability, one of the dependent variables of this study, has been defined as the degree to which the system can be used to achieve a specific goal by specific users with efficiency, effectiveness, and satisfaction (Bevan, Carter, Earthy, Geis, & Harker, 2016).

However, in this study, Shackel's usability model (1991) is adapted to measure LMS features' usability and to review the identified literature. This model was developed by Brian Shackel as a framework to enable a better understanding of usability evaluation and to measure users' tasks based on four criteria: learnability, flexibility, effectiveness, and user attitude (Joo, Lin, & Lu, 2011). Because the aim of this study was to investigate the effectiveness of certain LMS features' usability among learners enrolled in programming courses, the survey design was based on the components of Shackel's usability model (1991) in the interests of examining the effectiveness of VPL and discussion forums' usability as LMS features in terms of the four criteria mentioned. According to Preece (1993), usability can be measured and tested via several different approaches and techniques, such as expert/heuristic, observation, survey evaluation, and experimental.

Moreover, in previous studies, these four elements have been defined and classified in various contexts, including that of virtual learning environment or LMS use. For example, Koohang and Du Plessis (2004) defined the components of Shackel's usability model (1991) in their investigation, integrating usability methods and education to design an advanced LMS framework that could help create desirable learning environments. In so doing, the researchers, as in prior works, defined the four components as follows:

Effectiveness is defined by Koohang and Du Plessis (2004) as effective in an LMS when learners use it to successfully help themselves and accurately complete all tasks they have been assigned. Shackel (1991) defined it as the efficiency of tasks' completion in terms of the number of errors and the time taken. Nielsen (1993) described it by saying that the effectiveness of a system is directly related to its output; if the effectiveness of the system is high, the productivity will be high.

Flexibility is defined by Koohang and Du Plessis (2004) as flexible in an LMS when it can be adapted to reflect differences among, and revisions to, tasks and can help learners familiarize themselves with these alterations. Shackel (1991) defined it as accepting the adaptations and changes made to specific environments and tasks.

Learnability is defined by Koohang and Du Plessis (2004) as learnable in an LMS when learners can understand its features quickly and use it to execute tasks easily. Shackel (1991) defined it as the relationship between the frequency of system use and users' training performance. According to Nielsen (1993), learnability means that the system must be easy for users to learn or use and they should find it easy to execute their tasks.

Attitude: Students' attitude to an LMS is evidenced in their feedback on how it conforms to their requirements, such as those of agreement, happiness, and enjoyment (Koohang & Du Plessis, 2004). Shackle (1991) defined it as users' feedback and opinions on their use of a system in the aspects of personal effort, tiredness, and discomfort. According to Nielsen (1993), attitude is defined as users' satisfaction or feelings during, or after, using the system to complete a task.

Past Literature and Identification of Gaps

In previous studies, freshman-level students have been defined as "novice learners" or "first-year college students" and then categorized according to their learning attitudes. For instance, Perkins et al. (1989) classified novice learners into two main types of student based on how they responded to difficult aspects of a course: "stopper students" and "mover students." The former cannot move on or continue in the learning process when they experience difficulty learning content, whereas the latter can learn from instructor feedback and use it to further the learning process (Perkins et al., 1989**).**

Moreover, according to Koorsse (2015), novice programmers require greater skills to use programming languages and work in a programming environment. This is because the absence of

such skills can affect both their understanding of coding concepts and their development of programming skills. Novice programmers also need increased assistance to develop their ability to execute programming tasks and to better understand the principles of programming concepts.

The literature indicates that programming courses offer the most significant challenge facing novice learners enrolled in a computer science major. Such students may struggle to abstract the main concepts of programming topics, which are themselves a prerequisite for understanding program syntax and, ultimately, writing program code. Consequently, this unfortunate situation has encouraged researchers worldwide to conduct additional investigations with the aim of finding ways of reducing the difficulty inherent in programming courses. For example, Alakeel (2015), based on curiosity about the factors causing difficulties over learning computer programming in Saudi Arabia, designed a survey with which to examine learners' feedback based on three main indices related to learning environments and teaching methods. The researcher then distributed this survey randomly to students in three different universities in Saudi Arabia (Alakeel, 2015). The results of the survey showed, first, that students spend too little time practicing while learning programming, as well as too little time in laboratory sessions, and second, a lack of class activities, such as assignments and exercises, during which students could receive instructor feedback by 91% (Alakeel, 2015). However, the author's objective was to identify the factors causing the difficulty, not to find ways of decreasing it or to identify effective learning tools with which to fill the gap between this difficulty and the learning process, such as LMS features.

Analysis of the Research Methods Used

The literature shows that various authors have underlined the importance of researchers' and educational institutions' identification of an LMS learning method that can help learners improve their progress. In particular, several studies have shown that implementation and

integration of an LMS approach positively affects the learning process and learners' performance in higher education institutions around the world. For example, Davies and Graff (2005) investigated whether LMS-environment interactions could aid students in the learning process. These researchers examined 122 students enrolled at the University of Glamorgan, Wales, who had used the Blackboard LMS in their courses for 12 months; the authors also sought to identify LMS features' use for level one students (Davies & Graff, 2005). To do so, they used the Kruskal-Wallis test to correlate overall Blackboard use for each group of participants, using final grades as a measuring instrument for a range of courses. Their findings revealed that those students who failed their courses had used Blackboard the least and that those who passed with high marks had used the application the most (Davies & Graff, 2005).

According to the literature, most studies have focused on students experienced in LMS use and who are familiar with its functions. Notable among such articles is Holbl and Welzer's (2010) attempt to measure students' feedback and communication habits using Moodle LMS. These authors designed a survey in the form of a questionnaire for a sample of participants comprising 136 students from various courses. This survey targeted three main LMS functions: collaboration features, communication features, and wiki use in the Moodle LMS (Holbl & Welzer, 2010). Most participants were second- or third-year college students. Data analysis showed that, in general, students were not keen on using the communication tools or other Moodle features, with only 11% of them using discussion forums and 30% preferring to use the LMS communication feature (Holbl & Welzer, 2010). The feedback received as part of this study revealed that most students did not initially know how to use the LMS communication feature, with 70% preferring to use regular email to connect with their instructors. Furthermore, 40% preferred to submit their assignments in person or to send them by email (Holbl & Welzer, 2010). Notably, the results of

this examination of students' communication habits as regards the Moodle LMS failed to prove the effectiveness of LMS usability among this sample of participants.

Most researchers have examined the usability of LMS features in general terms, with few investigating the effectiveness of certain features that can help improve learners' performance in particularly challenging courses. In a general examination of LMS features, a study conducted by Sahid, Santosa, Ferdiana, and Lukito (2016) was aimed at evaluating and measuring the LMS user experience (UX) through application of a questionnaire tool. In this evaluation, LMS was examined in several categories such as attractiveness, dependability, and novelty. In their approach, the authors observed the LMS for two different semesters and applied two LMS types, which they called LMS1 and LMS2.

The data were collected from 38 learners who had experience in LMS use from taking two courses in an information technology program, which were a project management class and a risk management class. The results showed that, first, the user perception of LMS 1 and LMS 2 varied among the learners; and second, the quality level between the two LMS types was different. The only weakness of this study was that the LMS's features remained unknown during the LMS evaluation phase. The comparison between LMS 1 and LMS 2 was, in general terms, to identify which had a good level of quality.

Synthesis of the Literature

Previous studies indicate that the VPL is an essential pedagogical tool that may integrate with the LMS to implement the practical activities in programming courses remotely. For instance, Cavus, Uzunboylu, and Ibrahim (2006) carried out a pilot study at Near East University, Turkey**,** during the 2004–2005 fall semester. These researchers sought to create a virtual learning environment in which to teach programming languages using LMS features. An additional focus involved use of the Moodle LMS as a collaborative tool in two programming courses (for the Java

and Pascal programming languages) through its integration with other programming learning tools such as GREWPtool (Cavus et al., 2006). This integration between virtual learning features, dubbed the Near East University Virtual Learning Environment (NEU-VLE), was supported by the Moodle LMS.

Cavus et al. (2006) divided the learners into two groups according to programming language studied, hoping to discover whether the LMS features supported the objectives of these two courses. Thereafter, the researchers used a questionnaire-based survey containing 5-point Likert scale-type questions. In their analysis, they noted certain disadvantages of the NEU-VLE system and recommended that LMS systems include live video sessions to promote instructor-student and student-student interactions (Cavus et al., 2006). Importantly, participants reported that, when using the LMS, instructors were unable to perceive, through the students' body language, whether they understood the subjects (Cavus et al., 2006). The authors also observed that LMS use alone was not sufficient to deliver a realistic class environment or to facilitate exchange of feedback between instructors and learners.

The researchers also noted that the students in the Pascal programming language group were less satisfied with NEU-VLE than were their counterparts in the Java programming language group (Cavus et al., 2006). The reason given was that, because the compiler features in GREWPtool did not support Pascal syntax and code, students in this class could not run their programming exercises in the same way as could the members of the Java group. Accordingly, Cavus et al. (2006) concluded that, in general, an LMS integrated with other collaborative tools is most likely to recreate the characteristics of a real classroom.

One of the most important functions of VPL is the automatic assessment function. This feature helps students to improve their programming learning process by practicing their coding exercise before receiving automatic feedback on the same, including grading system instructors'

comments and their code evaluation. According to Prieto-Blazquez et al. (2009), the VPL automatic assessment process is an essential resource in programming because it supports the content's accessibility and availability, allowing students to execute their code remotely, anytime and anywhere. Moreover, it gives students feedback on their class programming activities, such as exercises and exams, in real time, which lets them know whether their code execution was successful.

The literature indicates that the use of LMS online discussion forums affords learners an opportunity to enhance their learning process through collaborative classes' discussion topics. A study conducted by Cho and Tobias (2016) was aimed at examining the effect of said forums on students' learning process as measured by three factors: learners' time on discussion forums, community of inquiry, and user satisfaction. The authors argued for a lack of empirical studies constituting investigations of the influence of the online discussion feature on learners' educational achievement. In the methodology of this study, the researchers used the same course for three consecutive semesters under three conditions. The first was that students take the course without using the discussion forums; the second was that students use the forums without instructor participation; and the third was that students use the forums with active instructor participation. During this experiment, the Blackboard platform was used as the LMS with which to deliver this course. The results showed that the condition of using the discussion forums with active instructor participation yielded excellent results in three factors: the time spent on the LMS, the course satisfaction, and students' academic achievement.

Furthermore, an empirical study conducted by Powell, Wimmer, Kilgus, and Force (2017) was aimed at investigating the effects of discussion forums in regards to learners' achievement of web-based assessments. In their approach, the authors applied the Aplia LMS to deliver Business Administration courses at the University of Pennsylvania, USA, before dividing learners

enrolled in business and technology courses into two groups (control/treatment). The results showed that the overall grades in the treatment group were higher than those in the control group and that the discussion forums motivated the learners in the treatment group to discuss the class topics.

Summary

As shown by these studies, various researchers have investigated and measured the effectiveness with which learners can use LMS features in a wide range of contexts and variables. Some have divided novice learners facing a difficult course into two types, stoppers and movers, with the former needing direct instructor support to continue the learning process effectively (Perkins et al., 1989). The theoretical foundation of this study is based on Shackel's usability model (1991), which measures the LMS's features' usability as a framework to enable a better understanding of usability evaluation via four criteria: learnability, flexibility, effectiveness, and user attitude. A review of the literature indicated that programming courses pose the greatest challenge for freshman-level students enrolled in a computer science major (Alakeel, 2015). Although some studies have failed to demonstrate that the usability of specific LMS features supports learners in this area, most have been focused on experienced students who had already used LMSs in their learning environment (Sahid et al., 2016). Furthermore, the VPL is one of the most important features that can be integrated with LMS functions to deliver programming courses. It offers both a collaborative tool for programming activities and an automatic assessment tool, which can enhance students' learning process (Blazquez et al., 2009; Cavus et al., 2006). In addition, the online discussion forums can augment said process by offering a collaborative feature with which to discuss the class topics and share knowledge (Cho & Tobias, 2016; Powell et al., 2017).

Chapter 3

Methodology

Research Approach

The methodology used in this study was a quantitative research-based approach to examining the usability of an LMS for freshman-level students who employ VPL and discussion forum features as well as these features' impact on the learning outcomes of programming courses. This involved the use of a quantitative quasi-experimental design including experimental (treatment) and control groups of new starts enrolled in an introductory programming course. The LMS's features were considered as a substitute for treatment in this experiment between participants in both groups who either used or did not use these particular features. At the end of the experiment, participants completed a survey that included questions about the post-test and Shackel's usability model (1991); these items were used to measure the LMS features' usability.

The students' final grades were used to measure the effectiveness, in terms of learning outcomes, of the use of certain LMS features between the two groups (Davies & Graff, 2005). The overall course grade included class activities such as programming exercises, class topics discussion, and the final exam. These activities were therefore identical for both groups.

Participants

This study targeted freshman-level students enrolled in an introductory programming course. These students were divided into two groups based on their use of LMS features. Each group included 30 participants. The treatment group used the LMS features selected for the study, including the VPL and discussion forums, while the control group used basic LMS features such as downloading class materials, sending messages and communications, and submitting exercise

files. The same course content and subject matter was presented to both groups. Such an approach allowed the evaluation of students' level of effectiveness at using certain LMS features based on participants' learning performance outcomes.

Weekly Groups Assessment

The groups had engaged in the programming course's activities, which would also be part of their assessment. The participants in the treatment group had used both LMS features—VPL and discussion forums—every week. They had used the former for practice and for submitting their programming exercises and the latter to reply to the weekly class discussion topic (Figure 1). Meanwhile, the control group had a traditional programming class style and the same weekly assessment based on their programming exercises and participation in the class discussion topic.

However, class activities for both groups were graded based on the following criteria: The total course score was 100%, which included the programming exercises with a weight of 35%, and all participants had seven exercises, distributed over seven weeks, each of which was worth 5%. The class discussion topics' responses were weighted at 35%; the seven class topics, also distributed over seven weeks, were each worth 5%; and the final exam had a weight of 30%.

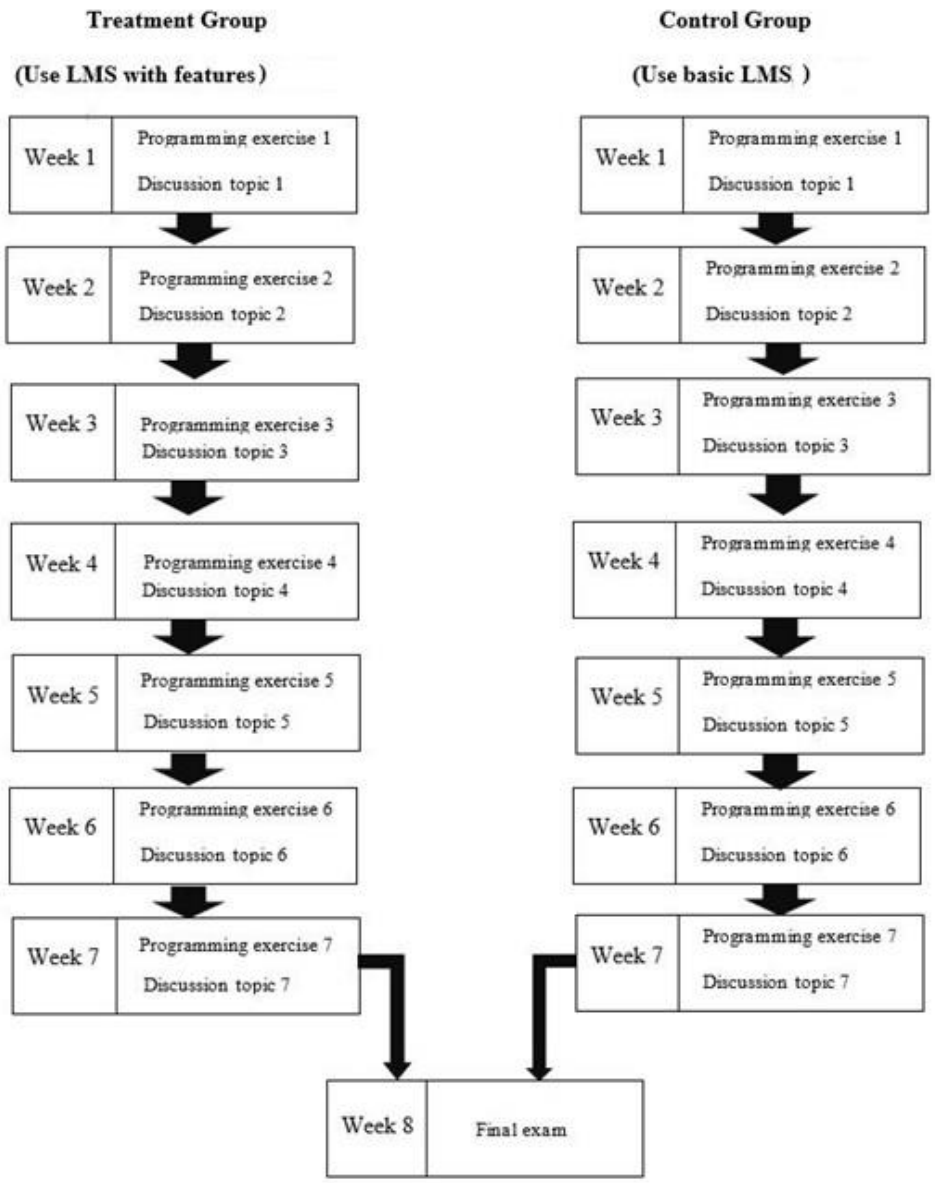


Figure 1: Weekly Groups Assessment Plan

LMS Environment Setup

Because the aim of this study was to investigate the effect of particular LMS features' usability on freshman-level students' learning outcomes in challenging courses. In one instance, Mhashi and Alakeel (2013) conducted a case study in which they investigated the complications facing students learning computer programming skills at the University of Tabuk, Saudi Arabia. The results showed that such difficulties included issues such as the use of programming languages. As such, the current study featured the use of an introductory programming course taught in the computer science department of the University of Tabuk to examine certain LMS features' usability's impact on freshman-level students' learning outcomes. Typically, the programming courses are offered in two different sections, one theoretical and the other **practical**; for the purposes of this study, in the **practical section**, the instructor used the VPL to deliver course content (Figures 2–3).

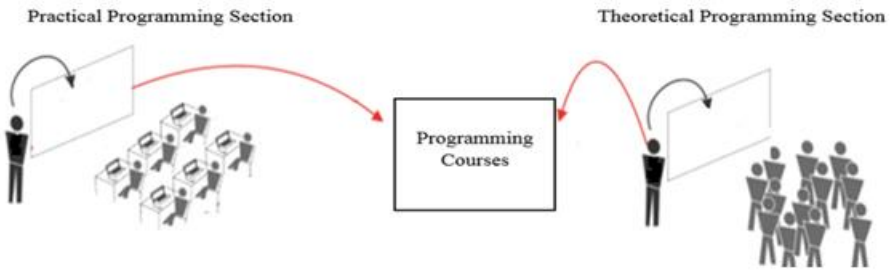


Figure 2: Types of Programming Classes

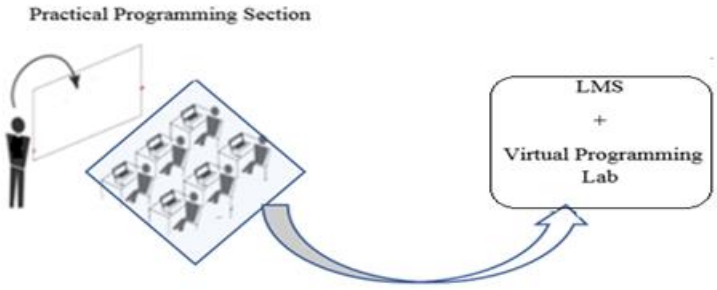


Figure 3: Integration of VPL into LMS

According to previous studies, a VPL plays a key role in practical programming courses' sections because it uses an automatic assessment system for programming activities in such classes, as well as an automatic grading code for class assignments, which facilitates instructors' timely evaluation of students' work and offering of feedback (Prieto-Blazquez et al., 2009).

Put simply, the VPL offers two access levels, one for instructors and another for students. Specifically, it allows instructors to design and administer programming class events by evaluating learners' programming activities, exercises, tests, or assignments. Instructors can also give students feedback in the form of written comments and edited and graded code. They can also see a list of timestamped student submissions and grade them accordingly (Figures 4–5).

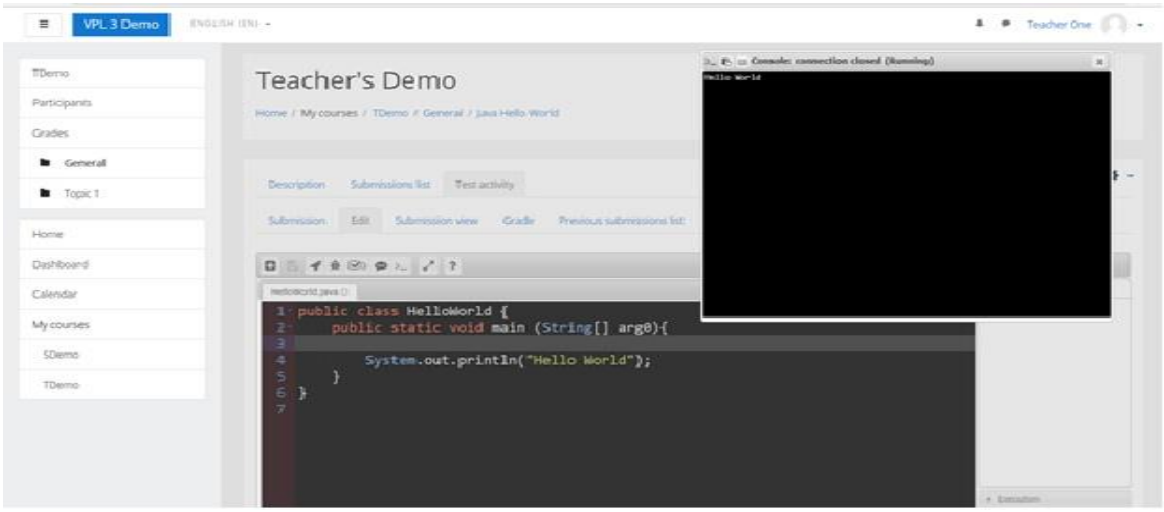


Figure 4. VPL Instructors' Dashboard View

After an instructor has finished designing a class module, students can join the class using their individual credentials. In each student's profile, he or she can view the student VPL dashboard, enabling tasks such as reviewing the instructor's guidelines for each programming task, submitting a work file, running the file via the VPL compiler, and waiting for the instructor's feedback (Figure 5).

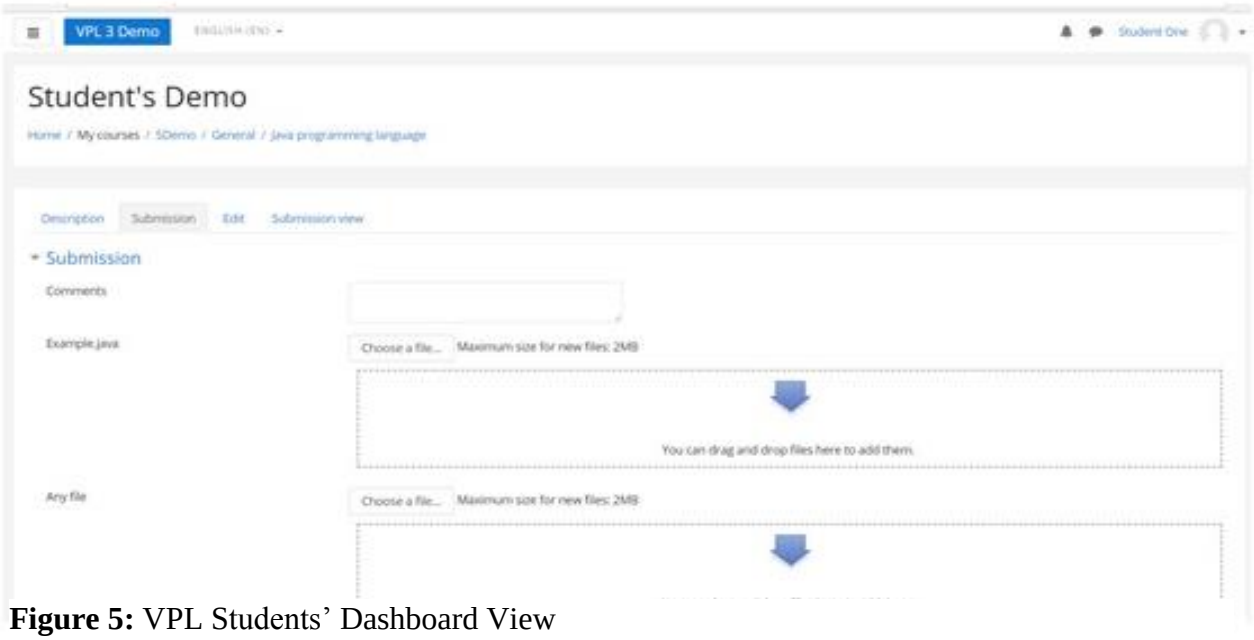


Figure 5: VPL Students' Dashboard View

However, the literature has shown that one of the most important features of an LMS is its ability to facilitate online participation via discussion forums. According to Shaw (2012), this feature allows the instructor to foster collaboration in class by posting a topic for learners' review and eventual discussion. Furthermore, said author classified the learners' attitudes, based on their participation level when using the discussion forums, as "replier user," "asker user," "no activity user," or "watcher user." In this study, discussion forums were the second LMS feature used to cover the theoretical topics in a programming course. The in-class topics were divided into eight sections, and each week, the learners had a specific programming topic that was discussed individually (Figure 6).

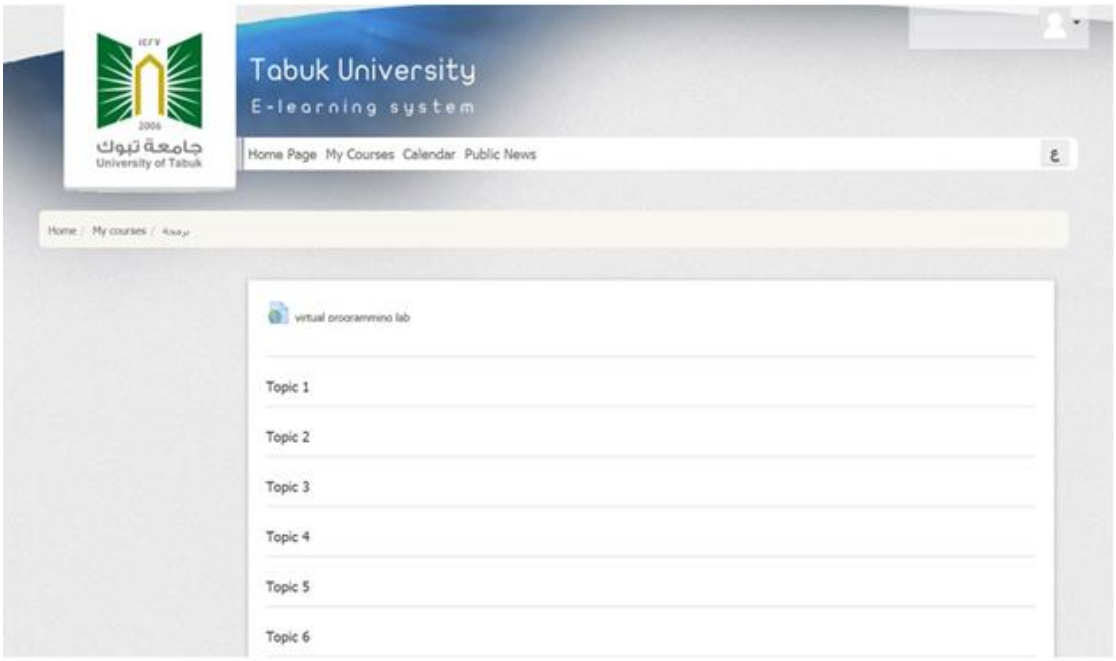


Figure 6: Discussion Forums in LMS

Data Collection

In this study, two groups of participants were followed for about eight weeks, during which time the participants in the experimental group used integrated LMS features (VPL and discussion forums) in their programming class activities. The main goal of this phase was to measure the research's dependent variables, which were the usability of LMS features and students' learning outcomes. For the first dependent variable, learning outcome, the final examination took place in the last week of the experiment, and the final grades for both groups were then compared to measure the students' rate of success (Chowdhry et al., 2014). In the control group (which used LMS without any features), the only data considered were the final grades. The overall grade data from both groups were then collated for comparison; the aim of this phase was to assess the course outcomes by comparing participants' final grades for this programming course.

For the second dependent variable, usability of LMS features, the participants completed a survey instrument to measure the components of Shackel's usability model (1991) on a 5-point

Likert-type scale (1 = strongly disagree to 5 = strongly agree). The survey was distributed via an online form to all participants. The survey design was based on the components of Shackel's usability model (1991) in the interests of examining the usability of the VPL and discussion forums features via the four constructs underpinning the model: effectiveness, learnability, flexibility, and attitude.

Data Analysis

Pre-analysis data screening used the SPSS software package to eliminate outliers from the data collected and to review said data for missing elements. Normality and linearity tests were also performed to evaluate the necessity of data transformations. This study featured the use of two types of analyses—descriptive analysis and *t*-test analysis—to analyze the data obtained from the surveys, and the resulting scores could thereby identify any statistically significant difference between these groups.

Resources

Although many resources were needed to conduct this study, specific hardware and software were not required. Any common LMS platform would have sufficed, whether Blackboard, Canvas, Moodle, or the like. Google survey forms were used to collect data, with the link to the survey made available to all participants. A data analysis application, such as SPSS Statistics or Smart PLS Statistics, was used to analyze the collected data. A VPL software package, with functions tailored to meet the requirements of programming courses, was made available to all students participating in this experiment.

The data used for this study were collected through an electronic survey administered to a sample of freshman-level students in the computer science department at the University of Tabuk. The final grade data for both groups of participants were required at the end of the experiment.

Considering these requirements, certain procedures had to be completed and permissions obtained before this study could proceed, chief among them the receipt of Institutional Review Board (IRB) study approval from Nova University. Additionally, the Participating Institution Study Approval form of the University of Tabuk had to be completed to apply for permission to conduct this study and its associated experiment and to obtain survey data and final grades of students from both groups of participants.

As noted, this study required the use of a data analysis application such as SPSS Statistics or Smart PLS Statistics. Similarly, the VPL tool was required to be used by participants for two months during the course of this experiment. Accordingly, the researcher needed to create a VPL environment suitable for programming courses before making it available to all students participating in the experiment. To make this possible, logistical support was required from the computer science department of the University of Tabuk to identify a programming course suitable for this experiment and to integrate the VPL and LMS platform that was used.

Chapter 4

Results

Introduction

This chapter contains the results that were obtained from the survey, as well as the students' reports and the statistical analysis outcomes. In this study, the participants were freshman students enrolled in an introductory programming language course (programming 101 C#) in the spring 2019 semester at the University of Tabuk. The study was conducted during eight weeks of the spring 2019 semester, and 60 students from three sections of the programming 101 course participated in the experiment. This experiment examined the effectiveness of LMS usability for freshman-level students who employ VPL and discussion forum features, as well as its impact on students' learning outcomes in programming courses. In a quasi-experimental design, the 60 freshman students were divided into two groups; 30 students were in the control group and 30 were in the treatment group. This chapter also addresses the results based on the research hypotheses as follows:

1. There are significance differences in LMS usability between freshman students who are using LMS features (VPL and discussion forums) in programming courses and those who are not.

2. There are significance differences in learning achievement between freshman students who are using LMS features (VPL and discussion forums) in programming courses and those who are not.

This study applied a five-point Likert scale to measure participants' responses regarding effectiveness, learnability, flexibility, and attitude. The Likert scale points were assigned correspondingly: Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree =

5. The participants' responses for each question were calculated to determine the highest mean for each response.

Pre-Analysis Data Screening

Pre-analysis and data screening identified one incomplete response that had been removed from the experimental group. Between both groups, 59 freshman students completed the experiment procedures: 29 students in the experimental group and 30 in the control group. Normality and linearity tests indicated that the data were normal, with data transformation figures were not necessary (Figure 7).

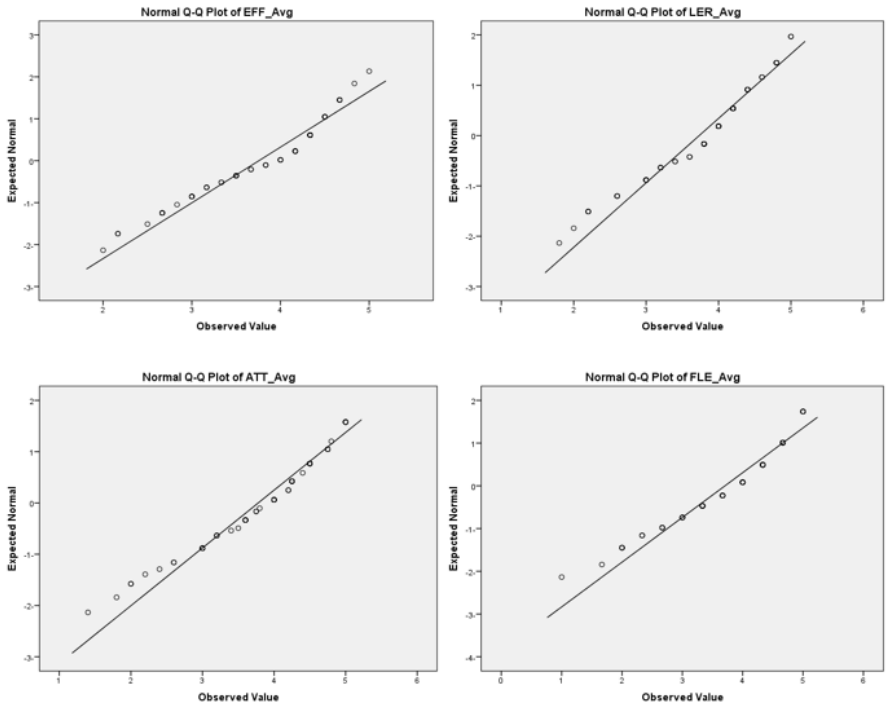


Figure 7: The Normality and Linearity Test Outputs

Demographic Data Analysis

This section discusses the demographic variables that were gathered from survey (Q1 - Q5) for both groups. The demographic information is presented in Tables 1-5. Table 1 shows the gender of the students who participated in the study. The data showed that in the treatment group,

51.7% of the participants were male and 48.3% were female. In the control group, 96.7% of the participants were male and 3.3% were female.

Table 1: Summary of Participants' Gender (N=59)

Group	Male #	Male %	Female #	Female %
Treatment	15	51.7	14	48.3
Control	29	96.7	1	3.3
Total	59			

Table 2 shows the education level of the students who participated in the study. The data indicated that in the treatment group, 100% of the students were freshmen. On the other hand, 96.7% of the students in the control group were freshmen; only one participant was at the sophomore education level.

Table 2: Summary of Participants' Current Education Level (N=59)

Group	Freshman #	Freshman %	Sophomore #	Sophomore %
Treatment	29	100		
Control	29	96.7	1	3.3
Total	59			

In addition, Table 3 shows the participants' level of programming knowledge. The resulting data indicated that in the treatment group, 100% of the students were novices. In the control group, 90% of the students were novices, and 10% had an intermediate level of programming knowledge.

Table 3: Summary of Participants' Level of Programming Knowledge (N=59)

Group	Novice #	Novice %	Intermediate #	Intermediate %
Treatment	29	100		
Control	27	90	3	10
Total	59			

Participants were also asked about their learning style, and Table 4 shows the learning style for the students who participated in this study. The results indicated that 29 of the participants in the treatment group, or 100%, had an online learning style. In the control group, 30 of the participants, or 100%, reported a traditional learning style.

Table 4: Summary of Participants' Learning Style (N=59)

Group	VPL style #	VPL style %	Traditional style #	Traditional style %
Treatment	29	100		
Control			30	100
Total	59			

Furthermore, in question 5, the participants were asked about their prior use of the LMS, and Table 5 shows the results from both groups. In the treatment group, 29 participants, or 100%, answered NO to question 5, saying that they had not used the LMS before. On the other hand, in the control group, 27 participants answered NO, and only three of the participants selected YES.

Table 5: Summary of Participants' Prior LMS Utilization (N=59)

Group	YES #	YES %	NO #	NO %
Treatment			29	100
Control	3	10	27	90
Total	3		56	

Data Analysis and Results

In this study, two types of analysis were conducted: descriptive analysis and independent samples *t*-test. Descriptive analysis was used to analyze the data collected using survey questions 7-25 in order to address the first research hypothesis. The independent samples *t*-test was used to determine the statistically significant difference in the data collected from the usability survey. Furthermore, the independent samples *t*-test was used to address the second research hypotheses in order to define the statistical differences in the overall scores resulting from both groups.

Research Hypothesis 1

Research hypothesis 1 stated: "There are significance differences in LMS usability between freshman students are using LMS features (VPL and discussion forums) in programming courses and those who are not." The data were obtained for the purpose of considering the usability of the LMS, which was measured based on the participants' responses to the components of Shackel's (1991) usability model: effectiveness, learnability, flexibility, and attitude (Appendix C). The effectiveness of LMS usability was gauged from the answers of the participants in both groups to (Q7 -Q12). The participants answered (Q13 - Q17) to gauge the learnability of LMS use, and (Q18 - Q20) measured the flexibility of LMS use among the participants. (Q21 - Q25) gathered information about the attitudes of the participants toward LMS use.

However, regarding the first hypothesis, the results of the independent samples *t*-test shown in Table 6 and Figure 8 indicate that there were significant differences in usability means in the treatment group's responses ($M = 4.25$, $SD = 0.25$) when compared to the control group for ($M = 3.22$, $SD = 0.70$) conditions, $t(57) = 6.72$, $p < .0001$

Table 6: Independent Sample *t*-Test Results of Usability (N=59)

Group	**N**	**Mean**	**Std. Deviation**	***t*-value**	***p*-value**
Treatment	29	4.25	0 .25		
				6.72	< .0001
Control	30	3.22	0.70		
Total	59				

Table 7 shows the results of the descriptive statistics test for usability model constructs for the treatment group responses: effectiveness ($M = 4.24$, $SD = .262$), learnability ($M = 4.20$, $SD = .329$), flexibility ($M = 4.21$, $SD = .482$), and attitude ($M = 4.35$, $SD = .425$).

Table 7: Descriptive Statistics Results of Usability Model for Treatment Group (N=29)

Construct	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Effectiveness	3.67	4.67	4.24	.262
Learnability	3.8	5.0	4.20	.329
Flexibility	3.33	5.0	4.21	.482
Attitude	3.5	5.0	4.35	.425

Table 8 shows the results of the descriptive statistics test for usability model constructs for the control group survey feedback. The results indicate that there was a significant difference in means between groups. The effectiveness response for the control group was less than the

treatment group by (*M* = 3.25, *SD* =.742), and in the learnability response, it was less than the treatment group by (*M* = 3.26, *SD* =.819). The flexibility response was less for the control group than the treatment group by (*M* = 3.18, *SD* = 1.38), and the attitude response in the control group less than the treatment group by (*M* = 3.20, *SD* =.856).

Table 8: Descriptive Statistics Results of Usability Model for Control Group (N=30)

Construct	Minimum	Maximum	Mean	Std. Deviation
Effectiveness	2.00	5.0	3.25	.742
Learnability	1.8	5.0	3.26	.819
Flexibility	1.00	5.0	3.18	1.38
Attitude	1.4	5.0	3.20	.856

Research Hypothesis 2

The purpose of this study was to examine the usability of the LMS for freshman-level learners who employ VPL and discussion forum features, as well as the impact of these two features on their learning outcomes in programming courses. For the dependent variable, the learning outcomes, the participants' final grades were measured to indicate learning outcomes for the participants in the two groups (Davies & Graff, 2005). Also, the total overall rate was 100%, which included seven programming exercises weighted 35%, seven class discussion topics weighted 35%, and a final exam weighted 30%. The data related to these activities were collected from both groups for seven weeks during the spring 2019 semester and the data from the final exam were collected during the eighth week of the experiment.

Research hypothesis 2 stated: "There are significance differences in learning achievement between freshman students who are using LMS features (VPL and discussion forums) in

programming courses and those who are not." For this research hypothesis, the independent samples *t*-test results in Table 9 and Figure 8 indicate that there were significant differences in overall score means, and the treatment group (M = 82.28 SD = 6.01) was greater than the control group by (M = 60.17, SD = 3.34) conditions, $t(57) = 18.31$, $p < .0001$

Table 9: Independent Sample *t*-Test Results of Overall Scores (N=59)

Group	**N**	**Mean**	**Std. Deviation**	***t*-value**	***p*-value**
Treatment	29	82.28	6 .01		
				6.72	< .0001
Control	30	60.17	3.34		
Total	59				

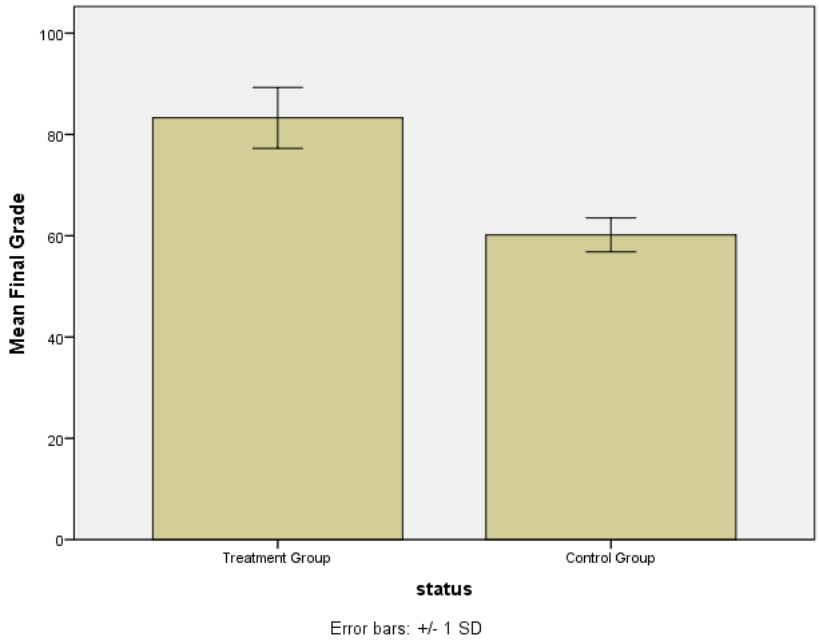


Figure 8*:* Independent Sample *t*-Test Results of Overall Scores Comparison

Summary

This chapter provides the results that were obtained from the participants in the experiment, all of whom are freshman students enrolled in (programming 101 C#) course in the spring 2019 semester at the University of Tabuk, Saudi Arabia. The data included the study survey responses, class activities reports, and statistical analysis outcomes with consideration for the two study hypotheses that were presented in chapter three. In the survey demographic questions, the participants were asked about their gender, their level of education, their level of programming knowledge, their learning style, and their prior LMS experience.

The participants in both groups answered (Q7 - Q25) to indicate their responses to Shackel's (1991) usability model components: effectiveness, learnability, flexibility, and attitude. After the data collection and the data pre-analysis had been performed, and normality and linearity tests were performed on the data and the results showed that the collected data was normal. Then, the descriptive analysis and independent samples *t*-test were performed to analyze the data collected from the treatment and control groups. The analysis output showed that there was a significant difference between the two groups in terms of LMS usability and learning achievement.

Chapter 5

Conclusions, Implications, Recommendations, and Summary

Conclusions

This chapter describes the conclusions, implications, and recommendations arising from the results of this study, based on the research problem and the study's goals. This study's limitations, and recommendations for future research, are also outlined. The chapter concludes with a summary of the findings of this study.

The research problem selected for this study addressed a gap in the literature left by previous studies' focus on experienced LMS users, with little attention paid to newcomers (i.e., freshman-level university students). Furthermore, although previous researchers have identified various ways of enhancing the effectiveness of LMS use, no consensus has yet been reached on which most successfully improves learning outcomes for new learners enrolled in programming courses.

The literature review revealed that numerous researchers have investigated and assessed the effectiveness with which learners can use LMS features in a wide range of contexts, considering many different variables. This research was grounded in Shackel's usability model (1991), which measures the usability of LMS features in terms of four criteria: learnability, flexibility, effectiveness, and user attitude.

The goal of this study was to evaluate LMS usability for freshman-level students who employ VPL and discussion forum features, as well as the effect on students' learning outcomes in programming courses. Accordingly, a quantitative research methodology in the form of an

independent-samples *t*-test statistical analysis was used to address two research hypotheses listed below:

1. There are significance differences in LMS usability between freshman students who are using, or not using, LMS features (VPL and discussion forum) in programming courses.
2. There are significance differences in learning achievement between freshman students who are using, or not using, LMS features (VPL and discussion forum) in programming courses.

The research experiment was performed over the course of eight weeks on freshman students in a programming course at University of Tabuk, Saudi Arabia. For the LMS usability data were obtained from the participants through a survey instrument. In addition, the data were collected through participants' class activities records in both groups. These activities were designed to measure the participants' learning achievements in both groups, which were distributed based on the experimental period as follows: seven programming exercises, seven class topics discussion, and final exam for all participants.

The first research question was amid to measure the first dependent variable, which was the LMS usability, based on Shackel's model elements including 19 survey questions. Questions (Q7–Q12) measured the effectiveness of LMS usability for participants in treatment and control group, whereas questions (Q13–Q17) measured the learnability with which participants learned to use the LMS. Questions (Q18–Q20) measured the flexibility of LMS use, and questions (Q21–Q25) measured the attitudes toward LMS use. In this study's first key finding, the independent-samples *t*-test showed significant differences in LMS usability among freshman students using VPL and discussion forum capabilities in the treatment group ($M = 4.25$, $SD = 0.25$) conditions, $t(57) = 6.72$, $p < .0001$, which supports research hypothesis 1. These results are consistent with

the findings of Alhazbi (2016), who found significant differences in LMS usability, user attitude, and satisfaction among learners using the LMS features in their programming courses.

For example, Alhazbi (2016) found that LMS use motivates learners in programming course environments to collaborate with class activities and to increase their level of interaction with their instructors. Furthermore, his study indicated that learners in programming courses are more comfortable when using LMS discussion forums to participate in class discussion topics. Moreover, the study's results were consistent with the second finding of Prieto-Blazquez et al. (2009), who recorded a significant difference among participants' feedback regarding the usability of VPL resources in programming courses. For example, LMS resources such as VPL can support learners taking programming courses in executing their code remotely and allow them to access their class content anytime and from anywhere. In addition, they found that LMS use helps students receive instructors' feedback on their programming work via an automatic assessment feature in real time, allowing students to track the success of their programming exercises.

The second research question aimed at measuring the second dependent variable—students' learning achievement. The measurement was based on participants' class activity data, including scores on programming exercises, discussion topics, and the final examination, for both groups. The second key finding of the independent-samples *t*-test showed a significant difference in learning achievement among freshman students who used VPL and discussion forum capabilities in the treatment group ($M = 82.28$ $SD = 6.01$) conditions, $t(57) = 18.31$, $p < .0001$, which supports research hypothesis 2. Furthermore, these results are consistent with those of Alhazbi (2016), Chowdhry et al. (2014), and Prieto-Blazquez et al. (2009), who found that LMS features can help learners improve their learning process. For example, Chowdhry et al. (2014) found that participants with a high level of LMS accessibility to course content saw a positive

impact on their learning achievement. In addition, Koorsse (2015) found that learners benefit in their learning process when they use LMS features, as found in the present study and in support of its second hypothesis. For instance, Koorsse discovered that learners in the treatment group who used VPL in programming class had higher mean tests results than learners in the control group when learning programming Looping concepts. Furthermore, he found that the students in the treatment group who applied VPL in their class activities perceived and understood the programing concepts more easily than those in the control group.

Study Limitations

The study's main limitation was that it only examined freshman-level students in programming courses and the impact of LMS features on LMS usability and learning achievement. Other demographic variables, such as participants' genders, were not included in the study's scope. Furthermore, according to the statistical descriptive analysis test results in Table 1, only 3.3 % of participants in the control group were female, while 96.7% of the participants were male. In addition, the data showed that in the treatment group, 48.3 % of participants in the were female, and 51.7% of participants were male. Therefore, the difference in gender among the participates in both groups might influence LMS usability in programming courses and learning achievement. Furthermore, Table 10 showed the Chi-square test results, which indicated a difference in the participants' LMS usability based on their gender.

Table 10: Summary of Chi-Square Tests Results N (59)

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	6.225[a]	3	.101
Likelihood Ratio	7.702	3	.053
Linear-by-Linear Association	2.654	1	.103
N of Valid Cases	59		

Implications

These findings could help universities around the world develop and design LMS features that will meet students' needs, in particular by easing freshman-level learners' transition into programming courses. Likewise, ensuring the usability of LMS functions could help boost the efficiency of the learning environments used in programming courses while improving outcomes for computer science programs.

Moreover, the findings of this experiment add to the body of knowledge about LMS research through an evaluation of the usability of users' experience and LMS functions. The resulting knowledge can provide a starting point for boosting the efficiency of learning environments in difficult courses while improving the quality of education programs' outcomes.

Recommendations for Future Research

The implications of this study's findings for the suggested research areas form the basis of certain recommendations. First, because this study examined LMS usability in freshman-level students, a similar study should be performed on participants in programming courses at different academic levels. Second, a further statistical test such as a Chi-squared test is needed to examine any relationship between demographic variables and the level of LMS features' usability among learners in programming courses and the impact on their learning outcomes.

Third, because this study was conducted in Saudi Arabia, similar research should be conducted in other developed countries, allowing comparison of outcomes. Fourth, because this study used Shackel's usability model (1991) to examine LMS features' usability in terms of four constructs—effectiveness, learnability, flexibility, and attitude—use of different usability constructs could strengthen its findings. Fifth, because this study focused on two LMS features—VPL and discussion forum—future studies should study different LMS functions.

Summary

The objective of this study was to evaluate LMS usability for freshman-level learners who use the VPL and discussion forum features, assessing the effect of these features on those students' learning outcomes in programming courses. The literature review revealed that the effectiveness of LMS features had already been investigated in a wide range of contexts and variables. Some researchers identified two categories of novice learners facing a difficult course: stoppers and movers (Perkins et al., 1989). The theoretical foundation for this research, being based on Shackel's usability model (1991), measured LMS functions' usability within that framework, using four criteria: learnability, flexibility, effectiveness, and user attitude.

The literature identified programming courses as the greatest challenge facing freshman-level learners in a computer science major (Alakeel, 2015). Furthermore, it revealed that some previous studies have failed to establish whether the usability of specific LMS features can support learners in a programming course, most having focused on experienced learners whose learning style already incorporated LMS use.

This study's quasi-experimental design encompassed two groups of freshman-level students enrolled in an introductory programming course. Participants were observed for a half-semester over the course of 8 weeks during the Spring 2019 semester at the University of Tabuk, Saudi Arabia. Significant differences in LMS usability were seen between these groups, with participants in the treatment group exhibiting greater learning than those in the control group. Building on this research, subsequent studies should investigate the usability of additional LMS features with a view to broadening understandings of this topic.

Appendices

A. Invitation to Participate

NOVA SOUTHEASTERN UNIVERSITY
College of Engineering and Computing

Invitation to Participate

You are being asked to take part in a study called Examining the Usability of Virtual Programming Lab and Discussion Forum Features for LMS's Impact on Learning Achievement for Freshman Students in Programming Courses. This study will be conducted by Mohammed Alatawi, a PhD student at Nova Southeastern University. The purpose of this study is to evaluate the usability of LMS's features for freshman-level students and their impact on students' learning outcomes in programming courses. The benefit of this study is that the researcher will be able to gather information in order to evaluate the usability of LMS's features.

The researcher will use the information that is gathered for statistical and summary purposes only. He will make certain that your name is not associated with your record. To the best of our knowledge, there are no physical or psychological risks associated with the procedures in this study. You are completely free to stop participating in the experiment at any time.

If you are willing to participate, please sign the attached informed consent form.

Please feel free to contact me if you need any further information.

Thank you,

Mohammed Alatawi,

(954)812-5703
Ma2024@mynsu.nova.edu

Appendix B

B. Informed Consent

Consent Form for Participation in the Research Study Entitled:

Examining the Usability of Virtual Programming Lab and Discussion Forum Features for LMS's Impact on Learning Achievement for Freshman Students in Programming Courses

Who is conducting this research study?

Mohammed Naif Alatawi is the principal investigator in this study. He will be helped by dissertation chair Dr. Wang, and committee members Dr. Sun and Dr. Hur, who are faculty members at the College of Engineering and Computing at Nova Southeastern University.

Why are you asking me to take part in this research study?

You are being asked to take part in this research study because you are a freshman-level student who is enrolled in introductory programming course. We expect around 30-50 students to participate in this study.

Why is this research being done?

The purpose of this study is to evaluate the usability of LMS's features for freshman-level students and their impact on students' learning outcomes in programming courses.

What will I be doing if I agree to participate in this research study?

The participants in this study will be placed randomly into two groups. One group will use the experimental LMS features in their programming course, and the other group will use the standard LMS features. Both groups will join this experiment for 8 weeks, and at the end of the 8-week period, all of the participants will take a one-time, anonymous survey. This survey will take approximately 10-15 minutes to complete.

Are there any possible risks or discomforts?

There are no physical or psychological risks associated with the procedures in this study.

What happens if I do not want to participate in this research study?

If you decide not to participate in this research study, it will not be held against you. You are completely free to stop participating in the experiment at any time.

Will my participation cost me anything? Will I get paid for being in the study?

There is no cost for participating in this study. Participation is voluntary, and no payment will be provided.

How will you keep my information private?

The information that we gather about you during the course of this research study will be handled in a confidential manner, within the limits of the law. This data is non-personally identifiable information and it will be available to the researcher, the institutional review board and other representatives of this institution, and any granting agencies (if applicable). All confidential data and participant records will be kept securely for a period of 36 months from the end of the study following Nova Southeastern University Institutional Review Board guidelines and recommendations.

Who can I talk to about the study?

If you have questions or concerns, or feel that this research has harmed you, you can contact Mohammed Alatawi at (954)-812-5703 or via email at ma2024@mynsu.nova.edu. You can also contact the dissertation chair Dr. Wang at lingwang@nova.edu.

If you have questions about the study but want to talk to someone who is not a part of the study, you can call the Nova Southeastern University Institutional Review Board (IRB) at (954) 262-5369 or toll free at 1-866-499-0790 or by email at IRB@nova.edu.

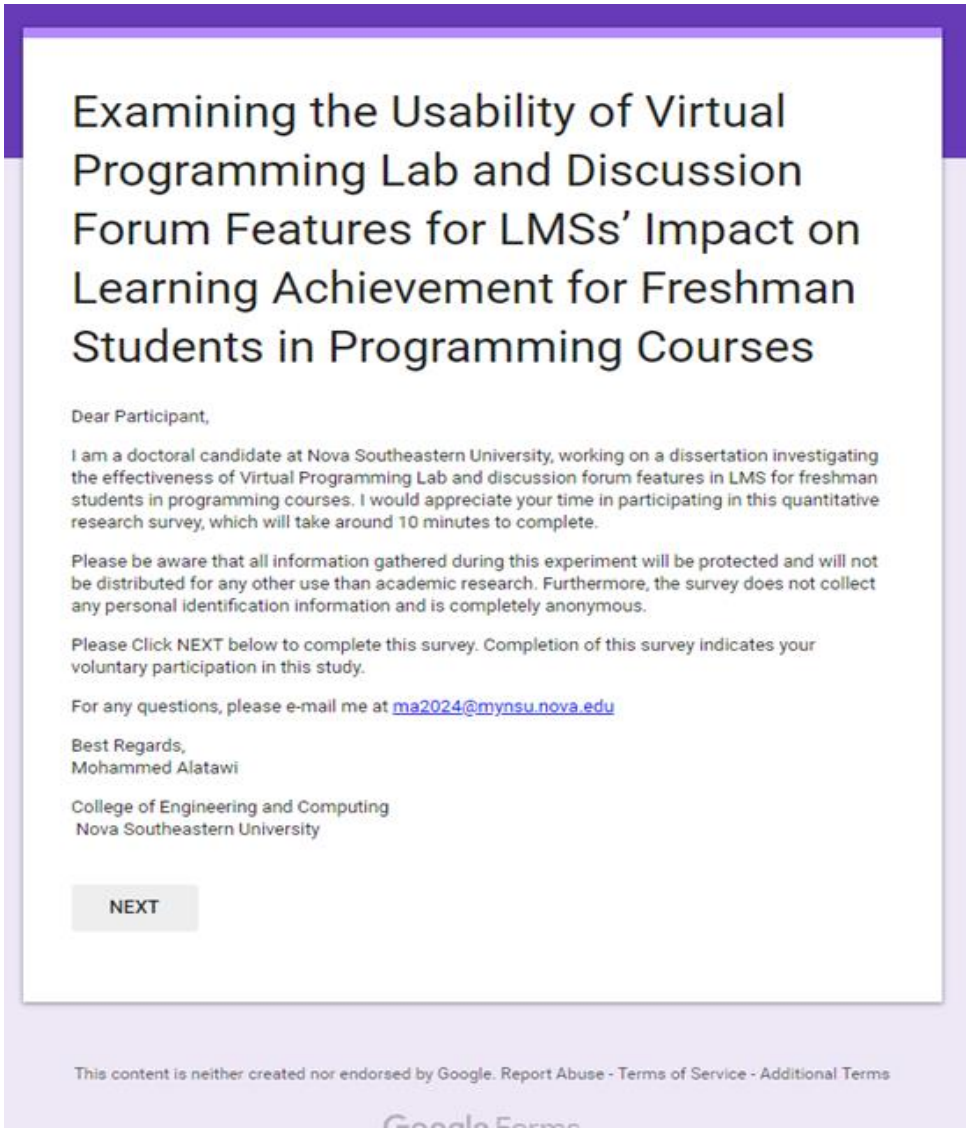
"I have read the above description of the experimental procedure and of my rights as a subject, and I have agreed to participate in the study on Examining the Usability of Virtual Programming Lab and Discussion Forum Features for LMS's Impact on Learning Achievement for Freshman Students in Programming Courses"

_____ Signature of Participant

_____ Date

Appendix C

C. Study Participants' Survey Instrument



Examining the Usability of Virtual Programming Lab and Discussion Forum Features for LMSs' Impact on Learning Achievement for Freshman Students in Programming Courses

Dear Participant,

I am a doctoral candidate at Nova Southeastern University, working on a dissertation investigating the effectiveness of Virtual Programming Lab and discussion forum features in LMS for freshman students in programming courses. I would appreciate your time in participating in this quantitative research survey, which will take around 10 minutes to complete.

Please be aware that all information gathered during this experiment will be protected and will not be distributed for any other use than academic research. Furthermore, the survey does not collect any personal identification information and is completely anonymous.

Please Click NEXT below to complete this survey. Completion of this survey indicates your voluntary participation in this study.

For any questions, please e-mail me at ma2024@mynsu.nova.edu

Best Regards,
Mohammed Alatawi

College of Engineering and Computing
Nova Southeastern University

NEXT

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Google Forms

* Required

Section 1: Demographics Information

D1. Gender *

- ○ Female
- ○ Male

D2. What is your current level of education? *

- ○ Freshman
- ○ Sophomore
- ○ Junior
- ○ Senior

D3. What is your current programming course level? *

- ○ Novice
- ○ Intermediate
- ○ Advanced

D4. What is your current learning style? *

- ○ Blended learning style (online)
- ○ Traditional learning style (face-to-face)
- ○ Hybrid learning style (mixed-mode Blended+Traditional)

D5. Have you used LMS prior to this class? *

- ○ YES
- ○ NO

D6. What is your Overall grade in this class? *

Choose

Please respond to the following statments from "1" to "5", with "1" indicating "Strongly Disagree", and "5" indicating "Strongly Agree"

Section 2: Effectiveness

EFF1. I received the course messages as specified by the instructor. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

EFF2. I was able to download my class material in reasonable time. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

EFF3. I was able to download my class material without errors. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

EFF4. I can effectively complete my class works by using LMS features. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

EFF5. LMS features have all the functions and capabilities that I expect it to have. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

EFF6. Overall, LMS features respond to my requests in reasonable time and without errors. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Section 3: Learnability

LER1. I do not need to learn a lot of things before I could use LMS features. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

LER2. The information provided by LMS features was easy to understand *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

LER3. It was easy to learn and use LMS features. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

LER4. There was too little information to be read, before I can use LMS features. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

LER5. Overall, these LMS features are easy to use. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Section 4: Flexibility

FLE1. I was able to download the learning material at anywhere and anytime through LMS features. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

FLE2. I was able to access my class learning material at anywhere and anytime LMS features. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

FLE3. Overall, I think LMS features are flexible. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Section 5: Attitude

ATT1. I feel comfortable using LMS features. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

ATT2. I will recommend LMS features to my colleague. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

ATT3. I enjoyed doing my task through LMS features. *

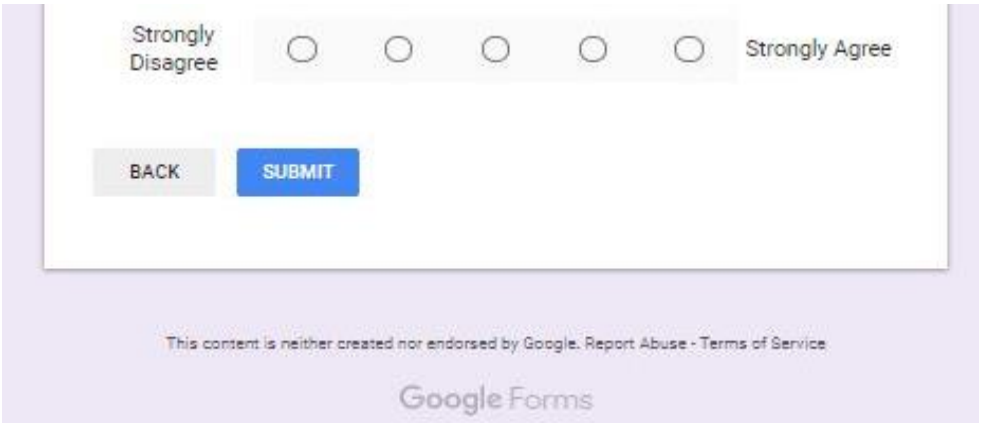
	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

ATT4. I feel that LMS features are user friendly. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

ATT5. Overall, LMS's features make it easy for me to access the required learning material. *

	1	2	3	4	5



Appendix D

D. Participating Institution Study Approval

KINGDOM OF SAUDI ARABIA
Ministry of Education
University of Tabuk
(052)

جامعة تبوك
University of Tabuk

المملكة العربية السعودية
وزارة التعليم
جامعة تبوك
(٠٥٢)

Dear **Mr. Alatawi**,

You have permission to conduct your study. Your study will make a valuable contribution to the extant literature.
We will serve as liaison at University of Tabuk and will assist you with any logistical issues during the data collection process. We wish you success in your doctoral studies and look forward to your findings.

Sincerely,

Majed AboRokbah Ph.D.

Dean, Faculty of Computers and Information Technology
University of Tabuk

Appendix E

E. IRB Approval Letter

NSU NOVA SOUTHEASTERN UNIVERSITY
Institutional Review Board

MEMORANDUM

To: **mohammed alatawi**

From: **Wei Li, Ph.D,**
Center Representative, Institutional Review Board

Date: **January 10, 2019**

Re: **IRB #: 2019-15; Title, "Examining the Usability of Virtual Programming Lab and Discussion Forum Features for LMSs' Impact on Learning Achievement for Freshman Students in Programming Courses"**

I have reviewed the above-referenced research protocol at the center level. Based on the information provided, I have determined that this study is exempt from further IRB review under **45 CFR 46.101(b) (Exempt 2: Interviews, surveys, focus groups, observations of public behavior, and other similar methodologies)**. You may proceed with your study as described to the IRB. As principal investigator, you must adhere to the following requirements:

1) CONSENT: If recruitment procedures include consent forms, they must be obtained in such a manner that they are clearly understood by the subjects and the process affords subjects the opportunity to ask questions, obtain detailed answers from those directly involved in the research, and have sufficient time to consider their participation after they have been provided this information. The subjects must be given a copy of the signed consent document, and a copy must be placed in a secure file separate from de-identified participant information. Record of informed consent must be retained for a minimum of three years from the conclusion of the study.

2) ADVERSE EVENTS/UNANTICIPATED PROBLEMS: The principal investigator is required to notify the IRB chair and me (954-262-5369 and Wei Li, Ph.D, respectively) of any adverse reactions or unanticipated events that may develop as a result of this study. Reactions or events may include, but are not limited to, injury, depression as a result of participation in the study, life-threatening situation, death, or loss of confidentiality/anonymity of subject. Approval may be withdrawn if the problem is serious.

3) AMENDMENTS: Any changes in the study (e.g., procedures, number or types of subjects, consent forms, investigators, etc.) must be approved by the IRB prior to implementation. Please be advised that changes in a study may require further review depending on the nature of the change. Please contact me with any questions regarding amendments or changes to your study.

The NSU IRB is in compliance with the requirements for the protection of human subjects prescribed in Part 46 of Title 45 of the Code of Federal Regulations (45 CFR 46) revised June 18, 1991.

Cc: Ling Wang, Ph.D.
Ling Wang, Ph.D.

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