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Attitudes of Saudi female students toward the use of mobile devices in learning computer programming: An empirical study

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ABSTRACT

The purpose of this study is to explore the attitudes of Saudi Arabian female students toward mobile learning approaches pertaining to their learning experiences. Our methodology involved two groups–one that was subjected to a traditional teaching approach and the other (treatment group) that was subjected to a teaching approach with an intervention involving the ViLLE visualization tool during a semester in a programming class. We employed the Mobile Learning for Computer Programming framework to evaluate the perception of the use of mobile devices pertaining to the learning experience of female programming students in Saudi Arabia. Overall, the treatment group had positive attitudes toward mobile-based learning. This approach can promote engagement in learning systems, enhance the learning experience, improve the quality of learning, and help explain learner behavior.

1. Introduction

The conventional learning practice of taking written notes in class is prevalent among female computer science students in colleges for women in Saudi Arabia. The modern approach of 'interacting with technology while learning' is considered to be more engaging than taking written notes in class. Most freshman-year female students at universities are known to face difficulties while studying computer programming. To counter this challenge and enable better classroom arrangements, colleges and universities for women in Saudi Arabia have resorted to encourage students to bring their own devices. This is implemented under the 'Bring Your Own Device' policy, which permits the students to bring personal devices, such as smartphones, laptops, and tablets, to the classroom for educational purposes (Brereton et al., 2009).

This paper evaluates the views of female Saudi Arabian students regarding the adaption/implementation of mobile learning approaches. It is important to understand the persistent social norms derived from the culture of Saudi Arabia to avoid any possible difficulty in the implementation of the said approaches.

Although some studies have attempted to gauge the attitude of students towards the use of mobile learning (Alsaggaf et al., 2012; Halim and Phon, 2020; Yallihep and Kutlu, 2020), there is a dearth of research related to investigating the cultural implications of using mobile learning in the context of computer programming education among female students in Saudi Arabia (Alfarani, 2016).

This study aims to identify the impact of the formal use of mobile devices on learning, acceptance, and engagement in classrooms as well as its cultural implications among female students in Saudi Arabia. To implement the teaching strategy for female Saudi Arabian programming students, the study utilizes the proposed Mobile Learning for Computer Programming (MoLeCop) framework for assessing mobile learning approaches. A software program with a visualization environment was chosen for this research to implement a mobile learning approach in a programming class as explained by Rajala et al. (2008) reporting the use of the ViLLE tool in their case study.

This study investigates the ways in which mobile-based learning and teaching approaches affect different attributes of the learning process, viz. engagement, learning experience, acceptance, and performance, among female Saudi Arabian students in programming classes.

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1.1. Proposed MoLeCop framework

In recent times, teaching and learning processes worldwide have incorporated mobile learning approaches, viz. m-learning and its associated tools. The mobile learning approach has emerged as an interactive interface in digital teaching methodology, focusing on the participation of the students in the program, their active engagement in lectures, and adding variation to the learning and teaching environment. Furthermore, the m-learning approach is customized to meet the needs of millennials (Loch et al., 2003).

The following four factors relating to computer-based learning environments need to be explored by researchers:

- Promoting engagement in the learning system
- Enhancing students' learning experience
- Making perceived usefulness (PU) positive
- Helping to understand learners' behavior

1.2. MoLeCop framework

The four-factor MoLeCop framework was used in this study to determine the factors that influence the use of mobile devices in lectures for programming classes. Fig. 1 shows a diagrammatic representation of this framework.

Each factor, its attributes, and its interrelations with the use of mobile devices for improving the learning experience of students are discussed as follows.

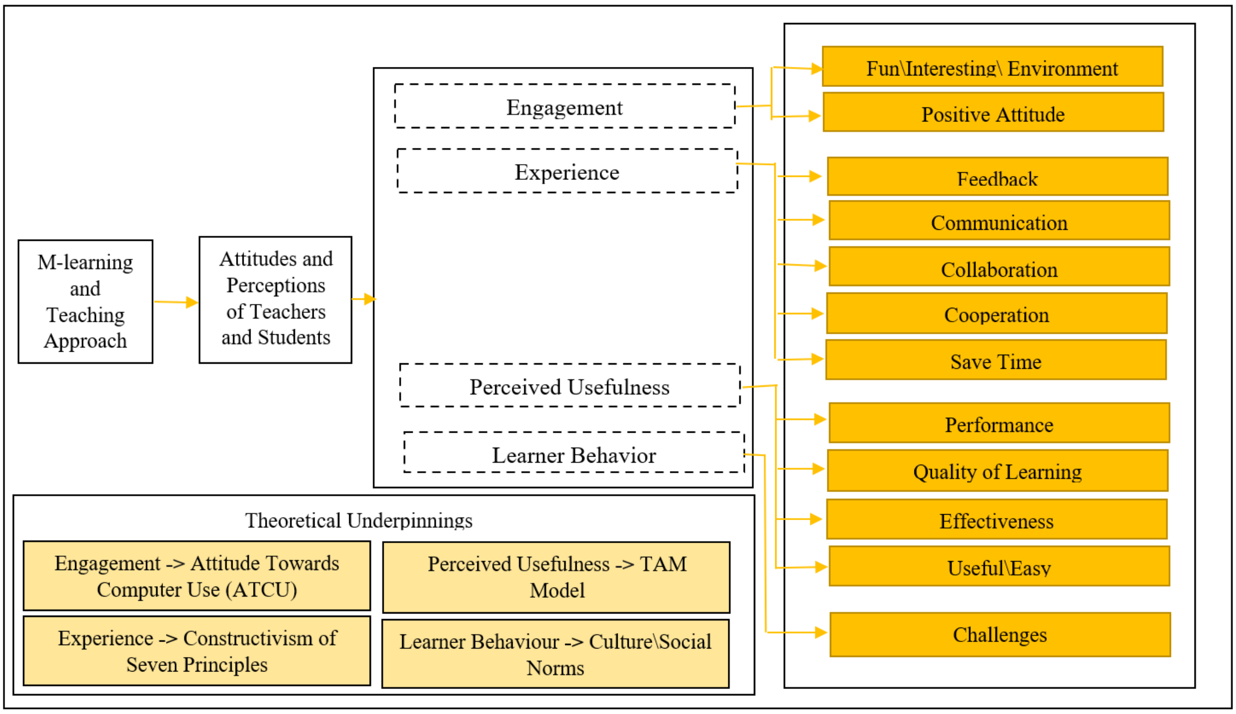

Fig. 1: Proposed MoLeCop theoretical framework

1.2.1. Promoting engagement in learning system

The level of engagement of students in technology has been greatly influenced by the perceptions and positive attitudes of teachers toward promoting the use of m-learning (Salloum et al., 2019). Students' engagement is described as the process that drives them to engage in a learning experience, thereby encouraging them to appreciate erudite attitudes (Packer, 2006; Camilleri and Camilleri, 2019). This factor is associated with students' enjoyment and their (positive or negative) attitude toward m-learning, alternatively known as attitudes toward computer use (ATCU).

1.2.2. Enhancing students' learning experience

Learning experience involving m-learning is aligned with the attribute of constructivism and the seven principles of effective learning approaches of mobile-based teaching as postulated by Chickering and Gamson (1987). Most lecturers opine that the attributes of feedback, collaboration, and time-saving are the most important factors in this regard.

1.2.3. Making PU positive

The concept of PU has been conceptualized and theorized in the technology acceptance model (TAM) as a vital element for students using ICT. The rationale of this concept is justified by the fact that PU supplements the determinants of technology use cases that can be examined in terms of behavior and intentions relating to technology usage. Most m-learning studies envisage technology use acceptance aligned with PU (Klawe, 1998).

1.2.4. Helping to understand learners' behavior

This study delves into the cultural factors that impact the Saudi Arabian women who wish to use m-learning approaches to study computer programming given that the use of m-learning and the internet are influenced by cultural beliefs and values (Walabe, 2020; Binsahl et al., 2020). Access to and engagement with programming subjects have various constraints for women, along with which the culture and traditions of Saudi Arabia also impact women's access to such technology and resources.

2. Methodology

The study was carried out at the School of Computer Science and Information Technology at Al-jouf University, where laptops were not required in lecture halls and the use of mobile devices was not facilitated by the infrastructure. The study was focused on students who were enrolled in a beginner-level Java programming course. The first semester of the academic year 2021 had a total enrolment of 42 students. With the population size being known, Krejcie and Morgan's (1970) method was used to determine the sample size. As 50 students were enrolled in two programming classes during the first semester of the academic year 2021, the sample size was determined to be 44. Out of this selected sample, 42 students completed the pre-intervention survey one week prior to the intervention. After this survey, these 42 students were divided into two groups of 21 students each. One group, classified as the traditional group, used the current learning method, while the other, termed the treatment group, used the mobile-enabled ViLLE visualization software tool as the learning method.

This was followed by the collection of quantitative data. The RedCap (www.project-redcap.org/) online survey software was used for the electronic distribution, collection of questionnaires, and Students' consent. Ethical approval was obtained before conducting the study (from The University Human Ethics Committee (UHEC), Research Office, La Trobe University, Victoria, 3086 (Phone: 9479 1443, E: humanethics@latrobe.edu.au Approval number: HEC19520). This study poses no risk to the students. Students were given information about the study before commencing the surveys. Each survey takes 10-15 minutes of students' time to be part of this study. Students were asked for their consent, which can be provided by starting the questionnaires. Pre-survey and post-survey tasks were used to validate the understanding of the learning experience of students. Each student of both groups was provided a pre-survey one week prior to intervention and a post-survey after it.

The ViLLE website (ville.cs.utu.fi) describes this software as a visualization learning tool developed by the University of Turku. Both students' and teachers' versions of this software are available on the website. This tool can be used to create and edit programming examples. Teachers also have the option to add programming examples and visualize their execution in the class or on the web. The events in the example can be seen during the execution of the program. This tool is primarily used to support beginner programmers in their learning. Furthermore, this software allows for viewing programming examples in different languages so students are able to understand the basic similarities among the languages. The 'programming language independency paradigm' suggests that instead of fixating on the syntactical issues of a specific language, new programming students should instead make efforts to understand the mechanisms underlying different programming concepts. Additionally, the ViLLE software provides numerous exercises along with visualizations to ensure the engagement of the students. For enhancing the learning experience, the prototype of this software is endowed with multiple choice questions, graphical array questions, general questions, graphical code line sorting exercises, and coding exercises. Many universities, across the globe, have adopted the ViLLE programming courses. The effectiveness of this software has been established by research indicating an enhancement in the learning of novice students.

The intervention process involved the traditional group using paper-based quizzes and the treatment group using the mobile-based learning approach towards learning programming, which was implemented by means of laptop computers with the ViLLE visualization software during quizzes. The students were novice programmers. The study groups are shown in Table 1.

Table 1: Numbers of students in the study groups

Groups	Tools	Number of students
Traditional group	Paper-based quizzes	21
Treatment group	ViLLE visualization software quizzes	21

2.1. Paper-based quizzes

The traditional group was given a paper-based examination having one question for each quiz. The final feedback from teachers was used for the development and evaluation of this examination. Each question was assigned 5 marks. Thus, the 15 total marks for the three quizzes formed a part of the total 100 marks for the whole course. An example of a paper-based quiz is presented in Fig. 2.

2.2. Computer-based quizzes

Similar to the quizzes of the paper-based class, each computer-based quiz also had one question for 5 marks and the 15 total marks for the three quizzes formed a part of the total 100 marks for the whole course. The students used the ViLLE platform to complete these three quizzes. The experiments were conducted during regular classes. An offline version of ViLLE was created because there was limited internet access during the lectures. Emails containing instructions to download the ViLLE software tool were sent to the students before the commencement of their classes. As a backup plan, a set of CDs and USBs was developed (for individuals who might be unable to access their e-mail). A screenshot, showing the methodology of intervention involving the ViLLE tool is depicted in Fig. 3.

Student Name:.. **ID:**................................

Quiz 3:

1. **Choose the correct answer for the following question:**
   Output:
   a. 22
   b. 12
   c. x+y is less than 10
   d. x+y is greater than 20

```
public static void main(String[] args){
  int x=10;
  int y=12;
  if(x+y<10){
    Sysetem.out.println("x+y is less than 10");
  }
  else{
    System.out.println("x+y is greater than 20");
  }
}
```

Fig. 2: Paper-based quiz

3. Data analysis

The two stages of data analysis involved analyzing the pre and post-survey data and performing a comparison between the traditional and treatment groups. SPSS Version 27 was utilized for entering and analyzing the quantitative data.

The first part of the survey contains questions relating to the demographic profiles of the students, their age, the status of laptop ownership, willingness to bring their laptops to university, and programming skills. Table 2 shows the information pertaining to the background of the student cohort.

In both groups of the cohort, the average student age is 19. The data show that 52.4% of the respondents in the traditional group are laptop owners, while 38.1% do not own laptops. However, among these, 9.5% are willing to purchase a laptop. In the treatment group, 57.1% of the students had laptops, while 42.9% did not have laptops. Additionally, the data show that 81.0% of respondents in the traditional group and 71.4% in the treatment group never or rarely carried laptops to school. Based on the student's responses regarding their programming ability, the majority were determined to be novice programmers. Their enrolment in the introductory programming course, which does not require prior programming experience, was further evidence of this. In both groups, 85.7% of students gave their programming experience a very low rating, whereas 14.3% gave it a medium rating.

3.1. Reliability testing

The degree of internal consistency and dependability among the four components of the analysis was calculated and examined in terms of Cronbach's alpha, a coefficient regularly used to evaluate and verify the dependability of tests. The value of this coefficient depends on the average correlation between the factors' items (Brown, 2002) and is considered satisfactory when it is more than 0.60 (Nunnally, 1994). Table 3 depicts the reliability of each tested factor.

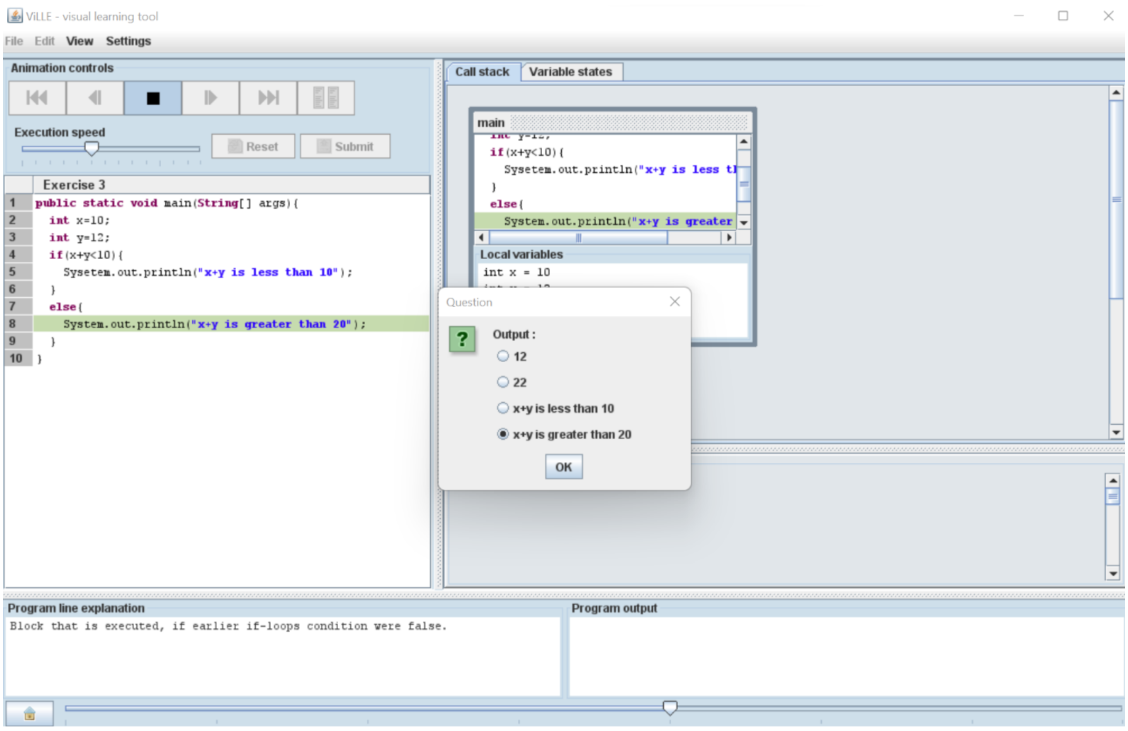

Fig. 3: Computer-based quiz

Table 2: Students demographics for 42 students

		Traditional Group	Treatment Group
N		21	21
Age	19	52.4%	66.7%
	18-20-21	47.6%	33.3%
Laptop ownership	No	38.1%	42.9%
	Willing to buy	9.5%	-
	Yes	52.4%	57.1%
Willing to bring laptop to university	Never	81.0%	71.4%
	Occasionally	19.0%	28.6%
Programming skill	Intermediate	14.3%	14.3%
	Novice	85.7%	85.7%

The findings show that the ATCU, the seven principles of constructivist teaching, and the PU of m-learning had an alpha coefficient higher than 0.70, and therefore, could all be regarded as having adequate levels of internal consistency and dependability. Contrarily, the dependability of social norms (0.526) was lower than 0.70. However, the number of items displayed under each factor could impact the value of Cronbach's alpha. For instance, Cronbach's equation may produce modest results when the factor has less than ten items. Reporting the items' mean inter-item correlation may be suitable in this case (Pallant, 2020). A scaled and ideal range for the inter-item correlation is from 0.2 to 0.4 (Briggs and Cheek, 1986). Inter-item correlations look at how closely the scores on one item correspond to scores on all other items.

3.2. Pre-survey

The pre-survey was completed by 42 students one week prior to the intervention. The second section of the survey, which included 26 items composed of 4 factors, was focused on the components of our suggested framework. The students were asked to rate their agreement with these statements on a Likert scale that ranged from 1 for 'strongly disagree' to 5 for 'strongly agree.' A score of 3 was regarded as 'impartial'. To determine whether there were significant variations in the views of the students towards the four criteria, a t-test was performed for each criterion. The two groups were considered to have statistically significant differences between them if the P-value (significance) was less than 0.5. The data for the traditional group (M=95.10, SD=25.94, n=21) and the m-learning group (M=91.71, SD=17.62, n=21) based on the student's responses are provided in Table 4. Furthermore, P=0.624 (P>0.05) implies that there were no statistically significant differences between the two groups.

Table 3: Reliability of the factors

Subscale	Number of items	Cronbach's Alpha	Inter-item correlation
Attitude toward computer use	8	0.928	-
Constructivism of seven principles	7	0.949	-
PU	8	0.948	-
Social norms	3	0.526	.32

3.3. Post-Survey

At the end of the semester, both groups were given the opportunity to respond to the same 26 items used in the pre-survey. As seen in Table 5, the data obtained by the analysis of factors indicate that there is a significant difference between the two groups following the treatment group's use of the ViLLE tool, which is made evident by the statistics for the traditional group (M=89.29, SD=16.69, n=21) and those for the m-learning group (M=103.62, SD=14.88, n=21). This difference is indicated by a P value of 0.033 for both groups. This outcome indicates that students' opinions of the MoLeCoP method were altered in the treatment group.

Table 4: Pre-survey statistics

Factors	Groups	N	Mean	Std. deviation	t	df	(P-value)Sig.
Student engagement	Traditional	21	30.48	8.89	0.557	40	0.580
	Treatment	21	29.14	6.42			
Student experience	Traditional	21	25.81	7.26	1.148	40	0.258
	Treatment	21	23.43	6.14			
Student PU	Traditional	21	30.24	8.97	0.213	40	0.833
	Treatment	21	29.71	6.84			
Challenges	Traditional	21	8.57	2.94	0.908	40	0.369
	Treatment	21	9.43	3.17			
All items	Traditional	21	95.10	25.94	0.494	40	0.624
	Treatment	21	91.71	17.62			

Table 5: Post-survey statistics

Factors	Groups	N	Mean	Std. deviation	t	df	(P-value)Sig.
Student engagement	Traditional	21	28.29	6.69	-2.358	40	0.023
	Treatment	21	32.81	5.70			
Student experience	Traditional	21	23.24	5.86	-2.619	40	0.012
	Treatment	21	27.43	4.40			
Student PU	Traditional	21	28.33	6.07	-2.030	40	0.049
	Treatment	21	32.19	6.24			
Challenges	Traditional	21	9.43	3.12	-2.212	40	0.033
	Treatment	21	11.19	1.89			
All items	Traditional	21	89.29	16.69	-2.938	40	0.0075
	Treatment	21	103.62	14.88			

3.4. Measures of effect size

We measured the effect size of the findings for the treatment group to show the influence of the factors on students' attitudes toward using mobile devices in programming classes. The effectiveness of the use of a mobile learning approach for teaching female programming students in Saudi Arabia was assessed using the effect size (Eta squared).

According to the findings shown in Table 6, there is a moderate effect seen in the treatment group for promoting engagement in the learning system in terms of ATCU, TAM factors such as PU, and understanding learner behavior in the context of Saudi Arabian social norms (Eta squared=0.122, 0.093, and 0.109, respectively). Students' perception of enhancing student learning experience (constructivist principles) can be seen to have a considerable impact on students' acceptance of mobile use.

Table 6: Measures of effect size

Factors	Eta	Eta Squared
Promoting engagement in learning system	.349	.122
Enhancing student learning experience	.383	.146
Making PU Positive	.306	.093
Helping to understand learner behavior	.330	.109
Total factors	.421	.177

4. Discussion

The attitudes regarding the use of laptop computers in university lectures have been extensively researched (Yallihep and Kutlu, 2020; Tan, 2019; Papadakis et al., 2021; Pan, 2020). In this study, we examined whether any significant changes could be observed by a comparison between findings obtained from pre- and post-intervention surveys involving students utilizing traditional learning techniques and those using mobile-based learning methods. The study focuses on the four factors of the MoLeCoP framework: ATCU, the seven principles of constructivist teaching, the PU of mobile devices, and social norms.

A substantial difference in attitudes was observed between the two groups regarding the usage of laptops. The students who used the ViLLE tool to complete their quizzes had attitudes indicating higher favorability towards the tasks than those of students who used conventional methods. The data in Table 5 show a significant difference with a P-value of 0.005 resulting from the treatment group's exposure to ViLLE. This finding indicates an improvement in the treatment group's perception of the MoLeCoP strategy. These results agree with those in the relevant published literature (Sahin and Yilmaz, 2020; Abdüsselam, 2014). The ViLLE software is known to be beneficial for mobile learning based on a multitude of reasons. First, implementing mobile learning makes the classroom environment more enjoyable (Jakkaew and Hemrungrote, 2017). Second, constructivist mobile learning is engaging and meets the needs of a new generation of students (Alsaggaf, 2013). Additionally, the PU can raise students' academic performance and quality (Smith et al., 2005). Davis (1985) considered PU as the extent of individuals' beliefs that their productivity will be improved by applying a particular solution (Rittgen, 2010). Furthermore, Davis (1985) and Taylor and Todd (1995) also demonstrated the relationship between PU and technology use cases. Thus, the perception of the usefulness of any new ICT tool–in this case, m-learning–to provide desired benefits has been the key determinant towards its use. It must be noted that this effect could be arising from a potential lack of obstacles or difficulties in adopting mobile learning; however, this is debatable (Al-Kandari et al., 2016). The tendency of social institutions to preserve culture is manifested in social norms and actions (Fishbein et al., 1980). The people's perception of modernization is influenced by culture; consequently, it affects their attitude toward technology (Bertolotti, 1984). It is crucial to have prior information about the culture-specific behaviors of the target population before introducing any new technology into a country or region (Loch et al., 2003). New technology can be aligned with the norms of the country if there is an a priori understanding of the culture of that country. In this way, the effects of cultural barriers that have the potential to stall the acceptance of technology can be overcome or mitigated. These factors collectively impact the opinions of teachers and students on utilizing mobile devices in lectures (Scherer et al., 2018).

In this study, we discovered that the constructivist principles of enhancing the student learning experience have the biggest impact on students' acceptance of computer use.

This outcome leads us to infer that students who are exposed to a mobile learning tool are more prepared than those who use the conventional approach. Therefore, the concept of 'learning experience' is defined as the impact of a program, interaction, or any other activity involving learning. The non-traditional methods of learning and teaching, such as m-learning, are widely perceived to be learner-centered rather than teacher-centered, and they have the capacity to increase learning potential. These methods are more interactive and activity-oriented (Alsaggaf, 2013). In addition, the mobile learning approach can enhance the learning experience, improve the quality of learning and help explain learner behavior.

4.1. Contributions

The specific research setting of Saudi Arabia and the influence of the prevalent social norms on teachers' intentions to use m-learning have been the focus of this paper, and new findings have advanced the extant literature. It is hoped that programming students in Saudi Arabia will benefit from these results, as they provide a reference to the literature for anyone seeking to adopt a mobile learning approach in programming classes.

Although there is a plethora of literature available on m-learning, acceptance studies suffer from a limitation in that many of the studies have only been conducted in Western contexts (Schepers and Wetzels, 2007; Traxler, 2007). This illustrates just how little evidence there is on applying the mobile learning approach in different cultures. This research, therefore, is a new attempt to apply the MoLeCoP framework in a non-Western culture, specifically in the context of programming courses in higher education in Arab countries.

In addition, determining and measuring user acceptance and the factors impacting this (Alsaggaf et al., 2012; Halim and Phon, 2020) have been the focus of many of the studies conducted on mobile learning in programming lectures, instead of validating those approaches through academic achievements. Thus, this research work endeavors to produce unique and valuable information by attempting to understand the effect of social norms, among other factors, in adopting m-learning in the Saudi Arabian context.

Alsaggaf (2013) discussed the acceptance of m-learning in programming classes; however, the effect of social norms on the acceptance of m-learning has not been addressed in her paper. Further, her work is largely silent on how and why the introduction of m-learning may affect Saudi Arabia's societal norms: it does not consider the challenges created when using ubiquitous devices while learning programming. Hence, because it addresses new issues, this paper plays a pivotal role in the context of research in this field.

Students with smartphones are commonplace these days, and they are eager to use this technology to advance their learning. However, female programming students in higher educational institutes of Saudi Arabia will suffer if m-learning is not formally adopted for them. Thus, it would be in the best interests of Saudi universities to find the right path through official authorization to foster the culture of mobile use for teaching and learning programming.

5. Conclusion and future work

This research aimed to evaluate the implementation of a mobile learning approach for female Saudi Arabian programming students' views using the MoLeCop framework. The findings showed that the treatment group had positive attitudes toward mobile-based learning. Moreover, we found that the enhancement of the learning experience has the most significant effect on the treatment group's views. Therefore, this approach can promote engagement in learning systems, enhance learning experience, improve the quality of learning, and help explain learner behavior.

Computer programming students in Saudi Arabia can benefit from this research's findings. This research can serve as a guide for anyone considering the use of a mobile learning strategy in their classrooms for programming courses. However, considering that a study based on a cohort from one university cannot address all aspects of implementing mobile learning approaches, such studies need to be replicated with a broader scope involving advanced programming classes.

Compliance with ethical standards

Ethical consideration

Ethical approval was obtained before conducting the study (Ethics reference: HEC19520) at La Trobe University.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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