




The use of mobile learning applications in higher education institutes

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Abstract

Higher education institutes are continuously exploiting technology to improve the delivery of courses. This paper reviews the use of mobile learning applications in higher education institutes to; i) identify publication trends, ii) types of mobile learning applications used, and iii) categorize the research papers published. The applied method is the Systematic Mapping Study. A Systematic mapping study was conducted using 103 papers retrieved from six different databases. The findings of this mapping study showed an increased research interest in the field and a variety of mobile learning applications used (learning management, vodcast and podcast, game-based learning, collaborative learning, and language learning applications). The published studies are mainly solution-oriented that focus on the use of mobile learning applications. The results were helpful to position future research activities.

Keywords Systematic mapping study · Mobile learning · Higher education

1 Introduction

Mobile learning is the use of portable devices such as smartphones, iPads, and tablets to provide anywhere, anytime learning experience (Cross et al., 2019; Kumar et al., 2019; Kumar & Mohite, 2016). With a large number of college and university students having access to these devices, mobile learning has become instrumental in this digital age (Diapopoulos & Crompton, 2020; Nefatti et al., 2021). Higher education institutes are continuously exploring technology to improve the delivery of courses (Crompton & Burke, 2018; Krull & Duarte, 2017). Many mobile learning research initiatives have been undertaken in colleges and universities over the years. In literature, there are many papers on the use

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of mobile learning in higher education institutes, but it lacks mapping of work done in this area. Motivated by this shortcoming, a systematic mapping study was conducted to study the use of mobile learning applications to establish substantial knowledge to guide the scholarly community. The systematic mapping study was conducted using the papers retrieved from eight digital libraries.

Systematic mapping study provides an overview of the field through counting and classifying the research contribution. It involves searching the published literature on the topic of interest, analyzing and producing reports to the scholarly community (Petersen et al., 2015; Petersen et al., 2008). Systematic mapping study has a well-established guideline that will help to structure the work and ensure the quality of results (James et al., 2016). The systematic mapping study was conducted to; i) identify publication trends, ii) types of mobile learning applications used, and iii) categorize the research papers published. Eight major publication databases were used to retrieve 124 papers. After assessing against inclusion and exclusion criteria, 103 papers were selected for the study. The results provided useful insight into the use of mobile learning in higher education. It showed an increased interest in research, a variety of mobile learning applications (learning management, vodcast and podcast, game-based learning, collaborative learning, and language learning applications) introduced in the higher education sector, and different categories of research conducted to study the use of mobile learning applications.

The systematic mapping study contributes to the body of knowledge through; i) counting and classifying contribution on the use of mobile learning applications in higher education and ii) consolidating the findings to set the direction for future research in the field. This article is structured as follows; the related literature section describes the use of mobile learning in higher education. The methodology outlines how the systematic mapping study was conducted. The results section reports on the analysis of data based on the research questions. The discussion section provides an interpretation of the results and derives the finding of the research to position future research activities. The limitations of the results are presented. Finally, the paper concludes with a summary of work done and setting the direction for future research.

2 Related literature

Mobile learning refers to the use of mobile devices to engage in learning activities (Traxler, 2005). Mobile learning is, therefore, synonymous with the provision of a learning environment which is ubiquitous in nature and empowers learners (Parsazadeh et al., 2018). Learners engaged in mobile learning can learn anytime and anywhere using wireless internet-enabled devices, such as smartphones, smartwatches, tablets, and digital audio players (Goksu, 2021; Kumar & Sharma, 2020; Kumar et al., 2020a). Mobile learning has transformed the face of educational technology globally, allowing learners to enjoy omnipresent access to educational resources and study autonomously (Tatnall, 2020; Duval et al., 2017). Hence, this approach provides opportunities to engage in learning outside the classroom (Tatnall, 2020).

Higher education institutes are going through a significant transformation, and the quest for effective teaching methods has resulted in universities increasingly exploiting technology to enhance the teaching and learning process (Al-Emran

et al., 2016). Mobile learning can be an instrumental tool in the transformation of the higher education sector. Mobile ownership amongst university and college students has exploded, and the majority of the students own more than one device (Crompton & Burke, 2018; Kumar et al., 2020b). Colleges and universities over the years have initiated numerous mobile learning projects. Examples include; Brata et al. (2019) developed a mobile learning app called "Hanasu" to be used by Indonesian higher education institutes to support the students learning the Japanese language. Oyeleru and Suhonen (2016) developed MobileEdu that facilitates the learning of computer science courses using mobile devices in the Nigerian higher education sector. Cruz et al. (2015) presented a game called '1910', which aims to identify the game habits of Portuguese students.

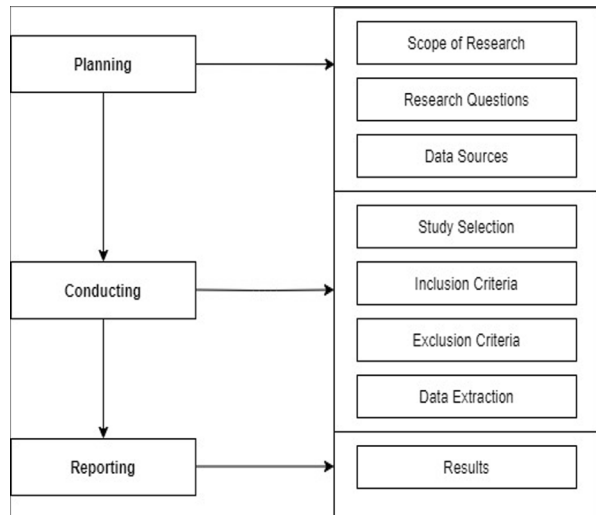
In the previous studies, Cheung and Hew (2009) reviewed research methodologies used to study mobile learning in the higher education setting. A total of 44 articles published until the end of 2008 were reviewed. The authors concluded that descriptive research was the most predominant research method, and the use of questionnaires was the standard data collection method. In another study by Kaliisa and Picard (2017), a systematic review was conducted in the higher education setting in Africa. The authors collated and compared studies to evaluate the impact, application, and challenges of mobile learning. The study found that mobile learning provided distance communication, increased student participation, increased student engagement, facilitated authentic learning, promoted reflective practice, and fostered learning communities. Krull and Duarte (2017) conducted a study to identify emerging trends in mobile learning for higher education. The motive of the study was to provide researchers and educators with an insight into research topics and issues. The study identified various research topics and themes that can be explored in mobile learning in higher education. Compton and Burke (2018) provided conducted a systematic review of mobile learning in higher education. The study outlined the purposes, methodology used, subject matter, educational context, educational level, geographical distribution, and device types of articles between 2010 and 2016. This study aims to focus specifically on the use of mobile learning applications in the higher education sector that investigates the types of mobile applications used and the research conducted to support the use of mobile learning applications in the higher education sector.

3 Research method

The systematic mapping study was carried out using the proposed guidelines of Petersen et al. (2015) and Petersen et al. (2008). The systematic mapping process consisted of three stages; (1) Planning, (2) Conducting, and (3) Reporting. Figure 1 illustrates the systematic mapping process.

- Planning stage—activities included identifying the scope of the research, research question, and data sources.

Fig. 1 Systematic mapping process



- Conducting stage—extracting relevant studies using the automated search strings and assessment against inclusion and exclusion criteria. Finally, data were extracted.
- Reporting stage—involved writing and communicating the results to the scholarly community.

3.1 Scope of research

The aim of this research is to build a substantial body of knowledge on the use of mobile learning applications in higher education; i) to identify publication trends, ii) types of mobile learning applications used, and iii) categories of research papers published.

3.2 Research questions

The research questions were identified, defined, and formulated to meet the objectives of the study. Table 1 provides the description of the research questions.

Table 1 Research Questions

Research Questions	Description
RQ1- What is the current state of research on mobile learning in higher education?	Investigates the publication trends and geographical setting of published studies
RQ2- What are the different types of mobile learning applications used in the higher education sector?	Investigates the different types of mobile learning applications used and different devices used to support these applications
RQ3- What are the different categories of papers published on the use of mobile learning applications in higher education?	Investigates different categories of papers published based on the framework proposed by Wierenga (2012)

Table 2 Data Sources

Digital Library	Uniform Resource Locator
Science Direct	https://www.sciencedirect.com/
Wiley Online	https://onlinelibrary.wiley.com/
IEEE Xplore	https://ieeexplore.ieee.org/
Taylor and Francis Online	https://www.tandfonline.com/
Springer Link	https://link.springer.com/
Inderscience Online	https://www.inderscienceonline.com/

3.3 Data sources

Digital libraries that publish papers in the field of information and communications technology were selected. Table 2 provides a list of leading scientific digital library databases utilized to search for related publications.

3.4 Study selection

An automated search string was executed on digital libraries to select research articles on the use of mobile learning in higher education. PICO (Population, intervention, comparison, and outcome) was used to determine the search string criteria (Schardt et al., 2007). PICO provides maximum coverage of the research area but in a manageable size. As per the research questions, the following search strings were identified and selected.

SS1: Mobile learning as the field of study.

SS2: Higher Education as the topic studied with the other search strings.

Table 3 shows the search strings used on the digital libraries. Alterations were done to the search string as the literature search proceeded. The search strings were refined, eliminated, and added to ensure all relevant papers were retrieved, and the search strings were re-run upon any changes.

3.5 Inclusion criteria

Inclusion criteria were used to assess the selected papers. Publications that met all the criteria listed below were included in the analysis of the results.

Table 3 Search String

Scope	Search Terms
Mobile learning	(mobile learning OR m-learning OR mlearning) AND
Higher Education	(Higher Educa- tion OR College OR University)

- IC1. The article reports on the use of smartphones, tablets, and other related devices.
- IC2. The article reports on the use of mobile learning applications.
- IC3. The study is based on higher education.

3.6 Exclusion criteria

Exclusion criteria were used to eliminate research papers. Publications that conform to at least one of the following were eliminated from the analysis of the results:

- EC1. The article is also listed in another database.
- EC2. The article is not written entirely in the English language.

Initially, 124 papers were selected, and after assessment against inclusion/exclusion criteria, 21 papers were removed. The selected papers are attached as Appendix 1.

3.7 Data extraction

Data were extracted from the primary studies using a data extraction form.

The following information was extracted from each of the primary studies.

- Year of Publication
- Publication Type
- Authors demographic profile
- mobile learning application used.
- Type of Paper (solution, philosophical, experience, validation, review)

4 Results

This section provides an in-depth analysis of the data obtained based on the three research questions that were identified earlier.

4.1 RQ1: What is the current state of research on mobile learning in higher education?

There has been growth in the study on the use of mobile learning in higher education. Studies in this area were initiated in the mid-2000s, and research has been ongoing for approximately two decades. Published papers and existing trends infer that study in mobile learning for higher education rapidly increased after the year 2010. Moreover, a significant number of research papers were published every year from the year 2010 and onwards. An increasing trend could

demonstrate the rate of technological advancement, especially with the introduction of smartphones. Smartphones produced and sold in the market came with better storage and processing capabilities. Moreover, mobile phones became a familiar and affordable household item that individuals preferred to own. More interactive and productive mobile applications were developed and used by individuals. Higher education providers began to explore options to utilize mobile phones in the teaching and learning process. There is nearly an equal distribution of journals and conference papers. Studies in this field are regarded as valuable scientific contributions. Some of the papers have been published in good quality journals with high impact factors, e.g., computers and education, and educational technology research and development. Figure 2 illustrates the publication trend, and Fig. 3 illustrates publication type.

The data was also extracted on the geographical setting of the published study. In the majority of the papers, it was clearly listed in which university the mobile applications were trialed; if it was not clearly mentioned, then authors affiliation was used to determine the geographical setting of the study. As illustrated in Fig. 4, studies on mobile learning in higher education are dominated by countries and continents that are more technologically advanced, for example, Asia and Europe. Moreover, it can be concluded that technologically advanced countries are at the forefront in mobile learning adoption in the higher education sector, while other countries are also showing keen interest to engage mobile learning in higher education.

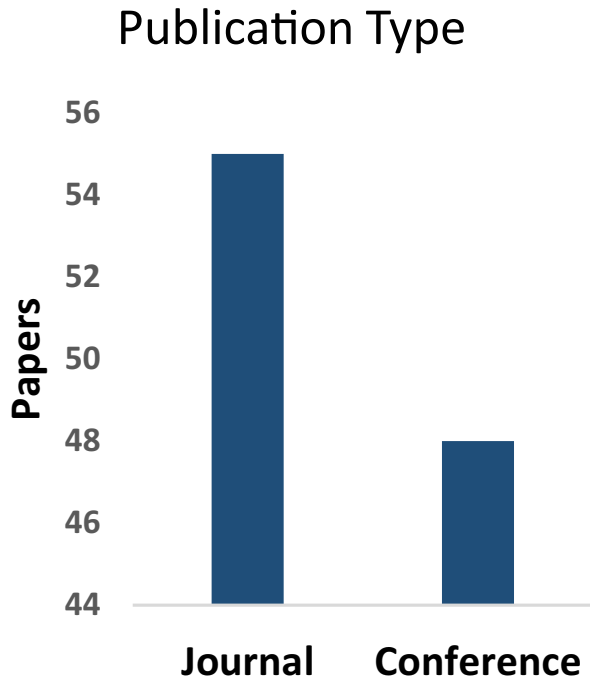
4.2 RQ2: What are the different types of mobile learning applications used in the higher education sector?

The mobile learning applications developed were trialed in the classrooms for undergraduate and graduate students. A variety of mobile learning applications were used to support teaching and learning in the higher education sector. Using thematic analysis, five categories were identified; learning management, vodcast and podcast, game-based learning, collaborative learning, and language learning

Fig. 2 Publication trend



Fig. 3 Publication type



applications. Figure 5 provides statistics on the use of mobile learning. From this, it can be identified that learning management applications, and vodcast and podcasts are widely used.

The individual categories are described below with the few examples of papers published in each category;

Learning management applications – these applications are used as the repository of learning resources. In some studies, moodle learning application was trialed and evaluated. e.g., Parsola et al. (2019) developed a mobile learning application for the storage and retrieval of lecture videos from mobile phones to the Hadoop Distributed File System (HDFS). Castillo et al. (2013) developed a Moodle LMS that

Fig. 4 Geographical setting of published studies

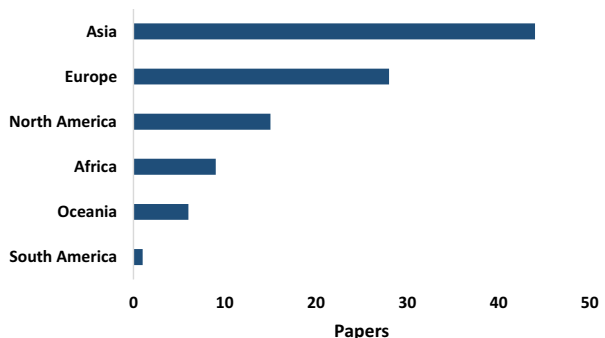
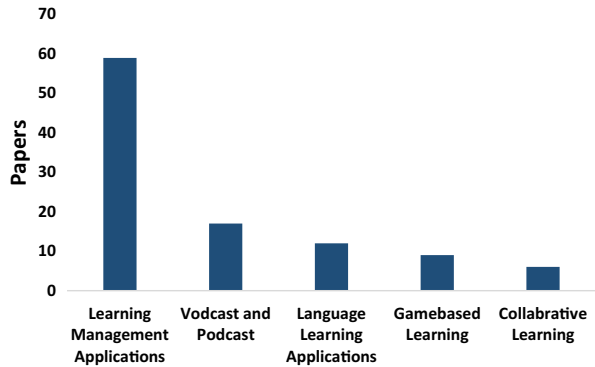


Fig. 5 Types of mobile learning applications

was used to bridge the gap between professors and students as well as the trends in higher education.

Vodcasts and Podcasts are applications used to deliver lectures to students. students can also download and listen to it post real-time lectures. The category includes features like video content (vodcasts), content sharing via social networking (social media), and audio content (Podcasts). For example, in a higher education study by Evans (2008), podcast was used for teaching undergraduate students; by downloading a series of audio and video files into digital media players.

Game-based learning – are applications where students are taught using mobile games. Mobile games can inspire learning to develop and enhance learning skills. For example, in a study by Troussas et al. (2020), "Quiz Time" (game-based learning application) was implemented. Quiz Time intelligently assesses and advances learners' knowledge in the programming language C#. In another study by Fotouhi-Ghazvini et al. (2009), two mobile games were designed to serve as a platform for self-study, assignments, and exercises for three different educational environments for Iranian language learners: schools, higher education, and government employees.

Collaborative learning- an application that uses techniques to enhance learning by facilitating students to work together. Collaborative learning can be achieved via the use of instant messaging and blogs to engage in mobile learning. For example, Davis (2014) conducted a study using the iPad to facilitate interaction and group cohesion within a series of tutorial sessions for a group of undergraduate nursing students. In another study, the use of a mobile-based social networking application was examined (Ng et al., 2020), "WeChat". WeChat supported collaborative learning and is considered the only mobile-based social networking application that a substantial percentage of Chinese students use.

Language learning applications- are applications that facilitate students to learn foreign languages. For example, in a study by Liu et al. (2015), a CAULL environment was developed to allow students to learn the surroundings of Cheng Kung Lake through handheld PDAs, wireless internet, RFID tags, and RFID readers. The study consisted of a total of 47 participants who were intermediate-proficiency-level graduate students. The researchers concluded that students benefited from using

Table 4 Paper category

Paper category	Description
Solution Paper	reports on the introduction of mobile learning applications in higher education
Philosophical Paper	introduces model or method for using mobile learning in higher education
Validation Paper	validates the use of mobile learning in higher education
Experience Paper	describes the authors' personal experience of the use of mobile learning in higher education
Review Paper	Review on the use of mobile learning in higher education

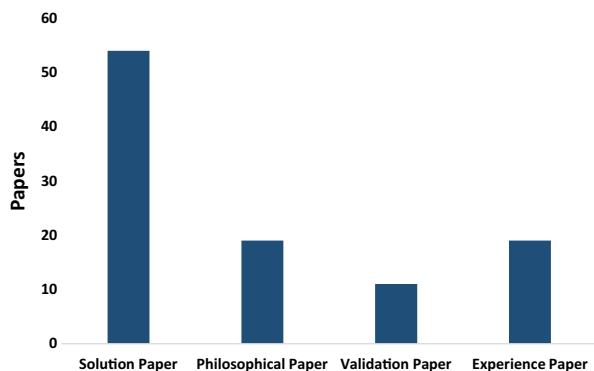
CAULL and improvised on receptive language skills. Moreover, the students demonstrated a positive attitude towards implementation.

4.3 RQ3: What are the different types of papers published on the use of mobile learning in higher education?

The papers were classified using the framework proposed by Wieringa et al. (2012). This includes five categories; solution paper, philosophical paper, validation paper, experience paper, and review paper. Table 4 describes each of the five categories.

The different categories are described in detail and supported by few examples extracted using systematic mapping process. There are some papers that were in both categories. Figure 6 illustrates statistical data on different categories. There was no review paper on the use of mobile learning applications in the higher education sector.

Solution paper discusses the introduction of mobile learning applications to improve the learning and teaching processes in higher education. For example, Andrei et al. (2019) gave insight into the Open Virtual Mobility Learning Hub. Open Virtual Mobility Learning Hub amalgamates several interactive technologies in an open-source learning environment, such as MOODLE. Zhou and Li (2019) propositioned a blended mobile learning environment to try out its pertinency in

Fig. 6 Categories of papers

theatre arts education. The authors presented and discussed the utilization of mobile devices in theatre arts classrooms in Macau.

Philosophical paper discusses new methods and techniques to support the use of mobile learning applications in higher education. In an article by Yunpeng (2011), a framework for assembling a mobile learning environment was designed. The learning environment was grounded on microblogging and cellular phones. Motiwalla (2007) also propositioned a framework. The framework gathers requirements to design and develop mobile learning applications to accompany classroom and distance learning.

Validation paper evaluates the use of mobile learning applications. Evaluations were mainly conducted to study acceptance and usability. For example, Evans (2008) measured the usefulness of mobile learning via podcast revision lectures in higher education. Hoi (2020) investigated the use of mobile phone services in the education sector. The attitude and expectation towards the use of mobile services at universities in Jordan were also explored. Hashim et al. (2011) evaluated the results of tests carried out on the MOSAD application. A heuristic test was conducted as the first version of MOSAD was developed. The heuristic test was aimed to strengthen the functionality and usability of the application.

Experience paper describes the author's experience in developing mobile learning applications. Gan et al. (2015) studied an iPad-based mobile learning project during a knowledge management course. The course contributed towards the university's technology-enabled learning vision. All experiences attained were reported. Martí and Ferrer (2012) presented research experience on learners' practices and insights on the usage of mobile portfolios as a methodological tool to evaluate learning in both formal and informal settings.

5 Discussion

The systematic mapping study provides substantial knowledge on the use of mobile learning applications in higher education. This study's main objective was to; i) identify publication trend, ii) types of mobile learning applications used, and iii) categorize the research papers published. While analyzing the publication trend, it can be noticed that there is a steady growth in the number of papers published in the field. The results were very similar to a previous analysis on the trend of publication by Crompton and Burke (2018), which also identified growth in the number of studies reported in the literature over the years. There is almost a similar number of papers published as conference proceedings and journal articles, and some of the papers have been published in very good quality journals. This attributes to the fact that studies on the use of mobile learning applications are regarded as a valuable contribution to the field of educational technology. Many of the studies are set in the developed countries in Asia and Europe. This can be due to the fact they are technologically advanced and have a high mobile penetration rate.

There are a number of mobile learning applications developed and trialed in the higher education sector. Thematic analysis was used to categorize this, and

five categories were identified; learning management, vodcast and podcast, game-based learning, collaborative learning, and language learning applications. Learning management application was the most popular category. Mobile learning applications were primarily used as a tool to provide learning resources to the students either in real-time or were available so that the students can see or listen in their free time. The variety of mobile learning applications used was also supported by the high penetration of mobile phones. Prices of mobile phones have been continuously slashed down over the years, making them more affordable for ordinary households and students. The papers were classified using the framework of Wieringa et al. (2012) that included; solution paper, philosophical paper, validation paper, experience paper, and review paper. Solution papers focused on the use of mobile learning applications. Philosophical papers included the use of frameworks, models, methods introduced to support the use or development of mobile learning applications for the higher education sector. Validation papers included studies that focused on acceptance and usability testing of mobile learning applications. Experience papers provide an analysis of the use of mobile learning applications in the higher education sector. This paper provides extensive knowledge on the use of mobile learning applications that can further assist researchers working in this field.

The findings of the study are important for subsequent research, and further work can be carried out to scientifically strengthen this field in the following ways;

- Specialized reporting – research is expanding in this area, and a large number of papers are being published. A specialized source of reporting in the form of a journal or conference proceeding would allow researchers to collaborate and develop solutions specifically related to the field.
- Systematic reviews – more reviews in the specialized areas need to be carried out. This can be used to examine the models and frameworks that have been proposed to support the use of mobile learning applications in the higher education sector.
- Models, Methods, and Frameworks – further research can be conducted in the field to design models, methods, and frameworks to study the use, implementation, or validation of mobile learning applications in the higher education sector.
- Comparative Analysis – performing analysis of mobile learning applications in higher education of developed countries. Best practices can be documented and utilized to develop mobile learning apps in developing and underdeveloped countries.

6 Limitations

The systematic mapping study was conducted by selecting studies from the six digital libraries that we considered publishers of good-quality studies in the field of information technology. Some relevant studies published in other journals and conference proceedings may have been missed. The mapping study also does not

include the thesis and other unpublished literature, but eventually, it may appear as conference proceedings and journal articles that can be included in the future iteration of this research.

7 Conclusion

This paper reports on the systematic mapping study carried out to establish a body of knowledge on the use of mobile learning applications in the higher education sector. The guidelines of (Peterson et al., 2008; Peterson et al., 2015) were followed to ensure quality results. In total, 103 papers were retrieved; the data analysis is provided in the results section and discussed further to provide recommendations for future research. In brief, the results showed an upward publication trend, a variety of mobile learning applications introduced in the higher education sector, and different categories of research conducted to support the use of mobile learning applications. This mapping study can be extended further to provide yearly updates to establish a stable body of knowledge.

Appendix 1

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